



CHEM · CHEMISTRY

07. Equilibrium

Official PMDC Solved Past Paper Topical Booklet · High-Yield Examination Series

101 Solved Questions

2010 to 2024 Archive

Boards: BUMHS, DUHS, KMU, MDCAT, NUMS, PMDC

Weightage: 27% of MDCAT (54 MCQs)

Curated by Ibrahim for fellow bees. Every question in this chapter has been verified against official UHS, NUMS, SZABMU, DUHS, and KMU answer keys. Propolis cognitive autopsies are provided at the end of this booklet to explain core concepts and break down common distractor traps.

OFFICIAL SOLVED EDITION**Q1.**

UHS 2024

The principle that states if a stress is applied to a system at equilibrium the system nullify the effect of stress as far as possible is:

- (A) Haber's
- (B) Le-Chatelier's
- (C) Boyle's
- (D) Charle's

Q2.

UHS 2024

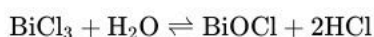
Identify the correct option required for the maximum yield of ammonia in Haber's process:

- (A) High pressure low temperature continual removal of ammonia
- (B) Low pressure low temperature continual removal of ammonia
- (C) High pressure high temperature continual removal of ammonia
- (D) High pressure low temperature continual addition of ammonia

Q3.

UHS 2024

Consider the following reaction in the equilibrium and tell addition of which will turn the cloudy solution into clear solution?



- (A) BiCl_3
- (B) H_2O
- (C) BiOCl
- (D) HCl

Q4.

UHS 2024

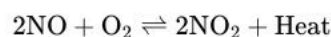
In endothermic reaction, the heat content of the

- (A) Reactants and products is equal
- (B) Reactants is more than that of products
- (C) Products is more than that of reactants
- (D) Reactants & products will not change

Q5.

SZABMU 2024

Chemical equilibrium given below will shift to backward direction by



- (A) Decreasing pressure and increasing temperature
- (B) Decreasing the temperature
- (C) Increasing the temperature
- (D) Increasing the pressure

Q6.

SZABMU 2024

Which of the following mixture will constitute the buffer solution?

- (A) Acetic acid & sodium acetate
- (B) Acetic acid & ammonia
- (C) Acetic acid and ammonium acetate
- (D) Ammonia & ammonium acetate

Q7.

SZABMU 2024

According to law of mass action, $K_p > K_c$ when reaction occurs with ____.

- (A) Decrease in volume on product side
- (B) Increase in volume on product side
- (C) Increase in volume on reactant side
- (D) Simultaneous increase and decrease

Q8.

SZABMU 2024

(Out of syllabus)

What will be the molarity of HCl solution with pH=4?

- (A) 0.0001
- (B) 0.0004
- (C) 0.004
- (D) 4

Q9.

SZABMU 2024

(Out of syllabus)

If weak acid is diluted with water, then H^+ ions concentration will ____.

- (A) Decrease
- (B) Gradually decreases then increase
- (C) Increase
- (D) Remain same

Q10.

SZABMU 2024

The pH of human blood is

- (A) 7.35 to 7.45
- (B) 8.35 to 8.45
- (C) 6.35 to 7.45
- (D) 5.57 to 6.57

Q11.

SZABMU 2024

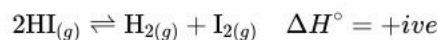
Maximum yield of ammonia can be obtained by

- (A) Low temperature, high pressure
- (B) Low temperature, low pressure
- (C) High temperature, high pressure
- (D) High temperature, low pressure

Q12.

KMU 2024

Which of the following factor will disturb chemical equilibrium in a given reaction?



1. Change in concentration
2. Change in temperature
3. Change in pressure
4. Change in volume

- (A) 1, 2
- (B) 3
- (C) 2, 3
- (D) 3, 4

Q13.

KMU 2024

The pK_a , of n-propyl amine is

- (A) 3.24
- (B) 3.28
- (C) 3.32
- (D) 3.35

Q14.

KMU 2024

Forward reaction is the one that

- (A) Is very slow at the beginning of the reaction
- (B) Reacts to form reactants
- (C) Speeds up gradually and at equilibrium its rate becomes constant
- (D) Takes place from left to right as given in chemical equation

Q15.

KMU 2024

In the production of SO_3 , from SO_2 and Oxygen, the yield of SO_3 , is increased by

- (A) Adding a catalyst
- (B) Adding more SO_2
- (C) Increasing temperature
- (D) Removing oxygen

Q16.

KMU 2024

Consider $N_2 + 3H_{2(g)} \rightarrow 2NH_{3(g)} \quad \Delta H = -92.46 \text{ kJ/mol}$
The optimum temperature, ($^\circ\text{C}$) to produce ammonia is

- (A) 0
- (B) 450
- (C) 5000
- (D) Constant temperature

Q17.

KMU 2024

The unit of K_c for the system $\text{PCl}_5 \rightarrow \text{PCl}_3 + \text{Cl}_2$ is

- (A) dm^3/mol
- (B) mol/dm^3
- (C) mol/dm^2
- (D) mol/dm^6

Q18.

DUHS 2024

The equilibrium of this reaction would not be affected by an increase in pressure

- (A) $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- (B) $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$
- (C) $2\text{NO} + \text{Cl}_2 \rightleftharpoons 2\text{NOCl}$
- (D) $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$

Q19.

DUHS 2024

The pH value of human blood is:

- (A) 7.8
- (B) 7.35
- (C) 7.33
- (D) 6.62

Q20.

DUHS 2024

The term "active mass" used in the Law of Mass Action means:

- (A) Number of moles per dm^3
- (B) Number of moles per liter
- (C) Gram per dm^3
- (D) Number of moles

Q21.

DUHS 2024

Conjugated acid NH_3 is

- (A) NH_4^+
- (B) NH
- (C) NH_2^-
- (D) NH_2

Q22.

DUHS 2024

(Out of syllabus)

According to Raoult's law, the relative lowering of vapor pressure is equal to:

- (A) Mole fraction of solute
- (B) Mole fraction of solvent
- (C) Molarity
- (D) Molality

Q23.

DUHS 2024

(Out of syllabus)

A colloidal solution of liquid into liquid is known as:

- (A) Solid foam
- (B) Foam
- (C) Fog
- (D) Emulsion

Q24.

BUMHS 2024

Le-Chatelier's principle does not give the information of effect of the following on equilibrium.

- (A) Time
- (B) Pressure
- (C) Temperature
- (D) Concentration

Q25.

BUMHS 2024

Equilibrium constant has no units, if the number of moles of product are

- (A) Less than reactants
- (B) More than reactants
- (C) Equal to reactants
- (D) Half of reactants

Q26.

BUMHS 2024

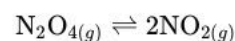
The sum of pH and pOH for pure water at 25°C is

- (A) 10^{14}
- (B) 10^{-14}
- (C) 14
- (D) 25

Q27.

BUMHS 2024

Suppose the following system has reached equilibrium at a certain temperature

Adding N_2O_4 to the system will

- (A) Start forward reaction
- (B) Start reverse reaction
- (C) Not disturb equilibrium
- (D) Raise the temperature of system

Q28.

NUMS 2024

The solubility of PbS at 25°C is 4.0×10^{-28} . Then ionic concentration will be:

- (A) 4×10^{-14}
- (B) 2×10^{-14}
- (C) 1×10^{-14}
- (D) 3.0×10^{-14}

Q29.

NUMS 2024

What conditions should be applied to minimize the leftover reactants in ammonia synthesis?

- (A) 200 atm, 500°C
- (B) 400 atm, 200°C
- (C) 100 atm, 400°C
- (D) 200 atm, 400°C

Q30.

NUMS 2024

Select the buffer solution having highest pH:

- (A) 0.1M CH₃COOH, 0.01M CH₃COO⁻
- (B) 0.1M CH₃COOH, 0.05M CH₃COO⁻
- (C) 0.1M CH₃COOH, 0.10M CH₃COO⁻
- (D) 0.1M CH₃COOH, 0.15M CH₃COO⁻

Q31.

UHS 2023

What is the ultimate fate of reversible reaction?

- (A) Completion of reaction
- (B) Complete consumption of reactants
- (C) Complete consumption of products
- (D) A state when there is no net concentration change

Q32.

UHS 2023

In reversible reaction, when product is removed, the equilibrium shift towards the:

- (A) Reactant side
- (B) Product side
- (C) Both side one by one
- (D) No effect

Q33.

UHS 2023

One can estimate the direction in which equilibrium will shift with the help of:

- (A) Le Chatelier's principle
- (B) Law of mass action
- (C) Mess's law
- (D) Law of heat of formation

Q34.

SZABMU 2023



- (A) Low temperature
- (B) High temperature
- (C) Continuous removal NH₃
- (D) Continuous addition of NH₃

Q35.

SZABMU 2023

What is not true about the Le-Chatelier's principle?

- (A) Allow to predict the change in concentration on system at equilibrium
- (B) Allow to predict the change in reaction rate on system at equilibrium
- (C) Allow to predict the change in pressure on system at equilibrium
- (D) Allow to predict the change in temperature on system at equilibrium

Q36.

SZABMU 2023

For a gaseous phase reaction, when number of moles of reactant and product are equal:

- (A) The values of K_p and K_c are different
- (B) The value of K_p is greater than K_c
- (C) The value of K_c is greater than K_p
- (D) The values of K_p and K_c are the same

Q37.

KMU 2023

Haber's process is used for the synthesis of ammonia. The optimum temperature for the Haber process is:

- (A) 35 – 50°C
- (B) 130 – 150°C
- (C) 400 – 450°C
- (D) 500 – 600°C

Q38.

KMU 2023

If ionic product is less than K_{sp} then:

- (A) Solution will be saturated
- (B) Precipitation will occur
- (C) Solution will be super saturated
- (D) No precipitation will occur

Q39.

KMU 2023

For $\Delta n = 0$

- (A) $K_p = K_c$
- (B) $K_p \neq K_c$
- (C) $K_p > K_c$
- (D) $K_p < K_c$

Q40.

DUHS 2023

Which of the following reactions has same value of K_c & K_p ?

- (A) $N_2 + 3H_2 \rightarrow 2NH_3$
- (B) $PCl_5 \rightarrow PCl_3 + Cl_2$
- (C) $H_2 + I_2 \rightarrow 2HI$
- (D) $2SO_2 + O_2 \rightarrow 2SO_3$

Q41.

DUHS 2023

Which of the following conditions required for maximum yield of ammonia through Haber's process?

- (A) Increasing temperature
- (B) Decreasing concentration of reactant
- (C) Decreasing pressure
- (D) Decreasing temperature

Q42.

DUHS 2023

Which of the following is true for reversible reaction at equilibrium?

- (A) The rate of forward reaction is greater than backward reaction
- (B) The rate of forward reaction is lesser than backward reaction
- (C) The rate of backward reaction is equal to forward reaction
- (D) The rate of backward reaction is greater than forward reaction

Q43.

BUMHS 2023

The solubility of $KClO_3$ is decreased by adding

- (A) KCl
- (B) $KClO_3$
- (C) H_2O
- (D) Not effected

Q44.

BUMHS 2023

The equilibrium stage that is not affected by temperature is called?

- (A) Static equilibrium
- (B) Natural equilibrium
- (C) Dynamic equilibrium
- (D) Unstable equilibrium

Q45.

BUMHS 2023

Temperature increase in an exothermic reversible reaction, shift the equilibrium to:

- (A) Product side
- (B) Reactant side
- (C) Remains unchanged
- (D) Increase in both

Q46.

NUMS 2023

The high pressure of 200 atm in Haber's process is used for:

- (A) Better yield
- (B) Lower yield
- (C) Lower rate
- (D) Coast decrease

Q47.

NUMS 2023

By which of the following factors equilibrium state is attained earlier?

- (A) Temperature
- (B) Pressure
- (C) Concentration
- (D) Catalyst

Q48.

UHS 2022

The decrease in solubility of the salt in a solution that already contains an ion common to that salt is known as:

- (A) Le-Chatelier's principle
- (B) Solubility product
- (C) Common ion effect
- (D) K_{sp}

Q49.

UHS 2022

The precipitation occurs if the ionic concentration is:

- (A) Less than K_{sp}
- (B) More than K_{sp}
- (C) Equal to K_{sp}
- (D) Present in any amount

Q50.

UHS 2022

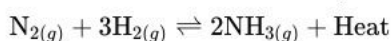
One can estimate the direction in which equilibrium will shift with the help of:

- (A) Le-Chatelier's principle
- (B) Law of mass action
- (C) Hess's law
- (D) Law of heat of formation

Q51.

SZABMU 2022

For the chemical reaction;



We can maximize the yield of NH_3 :

- (A) By increasing the temperature
- (B) By decreasing the pressure
- (C) By increasing the volume of the reaction vessel
- (D) By continuous withdrawal of ammonia

Q52.

SZABMU 2022

The high pressure of 200 atm in Haber process is used for:

- (A) Better yield
- (B) Lower yield
- (C) Lower rate
- (D) Cost decrease

Q53.

SZABMU 2022

By which of the following factors equilibrium state is attained earlier?

- (A) Temperature
- (B) Pressure
- (C) Concentration
- (D) Catalyst

Q54.

SZABMU 2022

Which of the following is not the use of the Buffer solution?

- (A) Used for the calibration of pH meters
- (B) Used to preserve biological specimen
- (C) Maintain the pH of the human blood
- (D) Predict the concentration of a substance

Q55.

KMU 2022

Buffer capacity is maximum when both components have:

- (A) High concentration
- (B) Equal concentration
- (C) Low concentration
- (D) High and equal concentration

Q56.

KMU 2022

If solubility product (K_{sp}) value is large the salt in water is:

- (A) More soluble
- (B) Less soluble
- (C) Moderately soluble
- (D) No concentration

Q57.

KMU 2022

The value of solubility products depends only on ____

- (A) Temperature
- (B) Solvent
- (C) Pressure
- (D) Catalyst

Q58.

DUHS 2022

In exothermic reaction, by decreasing the temperature, equilibrium constant:

- (A) Remains the same
- (B) Reaction moves backward
- (C) Decreases
- (D) Increases

Q59.

DUHS 2022

At equilibrium in a reversible reaction:

- (A) The rate of backward reaction > rate of forward reaction
- (B) The rate of forward reaction > rate of backward reaction
- (C) The concentration of reactant & products becomes constant
- (D) The concentration of reactants & products becomes constant & the rate of forward reaction is same as the rate of backward reaction.

Q60.

DUHS 2022

The solubility product K_{sp} predicts whether:

- (A) Diffusion
- (B) Solubility
- (C) Precipitation will take place or not
- (D) Boiling point

Q61.

BUMHS 2022

The precipitation occurs, if the ionic concentration is:

- (A) Less than K_{sp}
- (B) More than K_{sp}
- (C) Equal to K_{sp}
- (D) Present in any amount

Q62.

BUMHS 2022

Why a reaction is reversible?

- (A) Reactants are reactive
- (B) Products are reactive
- (C) Reactants are stable
- (D) Products are stable

Q63.

BUMHS 2022

Acetic acid is weak acid than sulphuric acid because of which of the following reasons?

- (A) It decomposes on increasing temperature
- (B) It has less degree of ionization
- (C) It has --COOH group
- (D) It has more inductive effect

Q64.

NUMS 2022

The pH of human blood is:

- (A) 7.35 to 7.45
- (B) 6.35 to 7.45
- (C) 8.35 to 8.45
- (D) 5.57 to 6.57

Q65.

NUMS 2022

Which term describes a solution in which dissolved solute is in equilibrium with undissolved solute?

- (A) Dilute
- (B) Unsaturated
- (C) Saturated
- (D) Supersaturated

Q66.

PMDC 2021

 $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$. Relation between K_p and K_c for this reaction is:

- (A) $K_p = K_c/RT$
- (B) $K_p = K_c$
- (C) $K_c = K_p/RT$
- (D) $K_p = K_c(RT)^{-1}$

Q67.

PMDC 2021

According to Le-Chatelier's principle, exothermic reactions are favored by:

- (A) Increase in pressure
- (B) Increase in volume
- (C) Decrease in temperature
- (D) All of these

Q68.

PMDC 2021

The equilibrium constant is always written as a ratio of:

- (A) Reactants over products
- (B) Product over reactants
- (C) Product times reactants
- (D) None of these

Q69.

PMDC 2021

Manufacturing of Ammonia by Haber's process is an:

- (A) Endothermic reaction
- (B) Irreversible
- (C) Exothermic reaction
- (D) Slow

Q70.

PMDC 2020

Which of the following reaction has greater K_p than K_c ($K_p > K_c$)?

- (A) $2\text{NO} + \text{Cl}_2 \rightleftharpoons 2\text{NOCl}$
- (B) $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- (C) $2\text{NOCl} \rightleftharpoons 2\text{NO} + \text{Cl}_2$
- (D) $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$

Q71.

PMDC 2020

The equation $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$ represents:

- (A) Contact process
- (B) Haber's process
- (C) Solvay's process
- (D) Avogadro's law

Q72.

PMDC 2020

For a gaseous phase reaction, when number of moles of reactants and products are equal:

- (A) The values of K_p and K_c are different
- (B) The value of K_p is greater than K_c
- (C) The value of K_c is greater than K_p
- (D) The value of K_p and K_c are the same

Q73.

PMDC 2020

Purification of table salt (NaCl) by passing HCl gas through its saturated aqueous solution is an example of

- (A) Law of mass action
- (B) Hess's law
- (C) Common ion effect
- (D) Henry's law

Q74.

SET 2019

Which one of the following factors does not affect the equilibrium position?

- (A) Catalyst
- (B) Concentration of reactants and product
- (C) Temperature
- (D) Pressure

Q75.

NUMS 2019

The K_c Unit for the reaction $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$ is:

- (A) $\text{mole}^{-1}\text{dm}^{+6}$
- (B) $\text{mole}^{-2}\text{dm}^{+3}$
- (C) $\text{mole}^{-2}\text{dm}^{+6}$
- (D) $\text{mole}^{-1}\text{dm}^{+3}$

Q76.

NUMS 2019

Which one of the following bases has highest K_b value?

- (A) NH_4OH
- (B) NaOH
- (C) $\text{Ca}(\text{OH})_2$
- (D) CH_3NH_2

Q77.

SET 2019

What is the pH of 0.1M of HCl?

- (A) 1
- (B) 0.1
- (C) 0.01
- (D) -1

Q78.

NUMS 2019

The pK_a values of CH_3COOH is 4.74, the pH of equimolar solution of acetic acid and sodium acetate is:

- (A) 13.0
- (B) 7.2
- (C) 4.79
- (D) 4.74

Q79.

NUMS 2019

Precipitation occurs when the product of ionic concentration is?

- (A) Greater than K_{sp}
- (B) Less than K_{sp}
- (C) Equal to K_{sp}
- (D) Equal to unity

Q80.

KMU 2019

Consider the reversible reaction. $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)} + \text{Heat}$

The yield of NH_3 will be maximum at:

- (A) High temperature and low pressure
- (B) High temperature and high pressure
- (C) Low temperature and low pressure
- (D) Low temperature and high pressure

Q81.

KMU 2019

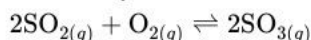
Ice and water is in equilibrium with each other. By increasing the pressure the equilibrium will shift in

- (A) Forward
- (B) Reverse
- (C) To all system at equilibrium
- (D) None of the above

Q82.

MDCAT 2019

For an equilibrium reaction;



The forward reaction is exothermic, increase in temperature shifts the equilibrium position towards left because:

- (A) The concentrations of SO_3 , SO_2 and O_2 increase as the temperature increases
- (B) The concentrations of SO_2 and O_2 increase and concentration of SO_3 decreases as the temperature increases
- (C) The concentrations of SO_2 and O_2 decrease and concentration of SO_3 increases as the temperature increases
- (D) The concentrations of SO_2 and O_2 increase and concentration of SO_3 stays same as the temperature increases

Q83.

MDCAT 2018

The product of the concentrations of each ion in saturated solution of a sparingly soluble salt at 298K raised to the power of their relative concentrations is:

- (A) K_{sp}
- (B) K_b
- (C) K_a
- (D) K_w

Q84.

MDCAT 2017

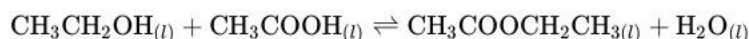
For which of the following equilibrium reaction, K_c has no units?

- (A) $\text{N}_{2(g)} + 3\text{H}_{2(g)} \rightleftharpoons 2\text{NH}_{3(g)}$
- (B) $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_{2(g)}$
- (C) $2\text{SO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{SO}_{3(g)}$
- (D) $2\text{NO}_{2(g)} + \text{O}_{2(g)} \rightleftharpoons 2\text{NO}_{(g)}$

Q85.

MDCAT 2017

Consider the following reversible reaction;



Initial concentration:

1 mol 1 mol 0 mol 0 mol

Equilibrium concentration:

0.333 mol 0.333 mol 0.666 mol 0.666 mol

 $K_c = 4$ at 100°C .

What are new equilibrium concentrations of all species if 1 mole of each of $\text{CH}_3\text{CH}_2\text{OH}$ and CH_3COOH are added to this equilibrium mixture? (Apply Le-Chatelier's Principle) (Temperature remained same)

- (A) $(\text{CH}_3\text{COOH}) = 0.333\text{mol}$, $(\text{C}_2\text{H}_5\text{OH}) = 1.333\text{mol}$,
 $(\text{CH}_3\text{COOC}_2\text{H}_5) = 1.666\text{mol}$, $(\text{H}_2\text{O}) = 0.666\text{mol}$
 (B) $(\text{CH}_3\text{COOH}) = 1.333\text{mol}$, $(\text{C}_2\text{H}_5\text{OH}) = 0.333\text{mol}$,
 $(\text{CH}_3\text{COOC}_2\text{H}_5) = 0.666\text{mol}$, $(\text{H}_2\text{O}) = 1.666\text{mol}$
 (C) $(\text{CH}_3\text{COOH}) = 0.666\text{mol}$, $(\text{C}_2\text{H}_5\text{OH}) = 0.666\text{mol}$,
 $(\text{CH}_3\text{COOC}_2\text{H}_5) = 1.333\text{mol}$, $(\text{H}_2\text{O}) = 1.333\text{mol}$
 (D) $(\text{CH}_3\text{COOH}) = 0.333\text{mol}$, $(\text{C}_2\text{H}_5\text{OH}) = 0.333\text{mol}$,
 $(\text{CH}_3\text{COOC}_2\text{H}_5) = 1.333\text{mol}$, $(\text{H}_2\text{O}) = 1.333\text{mol}$

Q86.

MDCAT 2017

$\text{Ca}(\text{OH})_2$ is sparingly soluble having solubility product value 6.5×10^{-6} . What will be its solubility?

- (A) 2.75×10^{-2}
 (B) 1.17×10^{-2}
 (C) 2.75×10^2
 (D) 3.63×10^3

Q87.

MDCAT 2016

Human blood maintains its pH between:

- (A) 6.50 – 7.00
 (B) 7.50 – 7.55
 (C) 7.20 – 7.25
 (D) 7.35 – 7.40

Q88.

MDCAT 2016

Value of K_{sp} for PbSO_4 system at 25°C is equal to:

- (A) $1.6 \times 10^{-5} \text{ mol}^2\text{dm}^{-6}$
 (B) $1.6 \times 10^{-8} \text{ mol}^2\text{dm}^{-6}$
 (C) $1.6 \times 10^{-6} \text{ mol}^2\text{dm}^{-6}$
 (D) $1.6 \times 10^{-7} \text{ mol}^2\text{dm}^{-6}$

Q89.

KMU 2016

 $K_p = K_c(RT)$ in the equation if $\Delta n < 0$ then:

- (A) $K_p = K_c$
 (B) $K_p < K_c$
 (C) $K_p > K_c$
 (D) $K_p < 0$

Q90.

KMU 2016

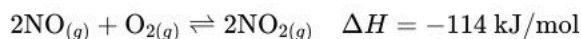
pK_a values of some acids are given below; choose the weaker acid?

- (A) HClO_4 (–10)
 (B) HBr (–9)
 (C) H_2SO_4 (–3)
 (D) HCl (–7)

Q91.

MDCAT 2015

During the manufacture of nitric acid, nitric oxide is oxidized to nitrogen dioxide. This reaction is given as:



According to Le Chatelier's Principle:

- (A) Reaction must not be temperature dependent
 (B) Reaction must be carried out at room temperature
 (C) Reaction must be carried out at low temperature
 (D) Reaction must be carried out at high temperature

Q92.

MDCAT 2015

What is the correct relation between pH and pK_a ?

- (A) $\text{pH} = \text{pK}_a + \log \left(\frac{[\text{Acid}]}{[\text{Base}]}\right)$
 (B) $\text{pH} = \text{pK}_a - \log \left(\frac{[\text{Base}]}{[\text{Acid}]}\right)$
 (C) $\text{pH} = \text{pK}_a - \log \left(\frac{[\text{Acid}]}{[\text{Base}]}\right)$
 (D) $\text{pK}_a = \text{pH} + \log \left(\frac{[\text{Base}]}{[\text{Acid}]}\right)$

Q93.

MDCAT 2015

Which one of the following is the correct representation for K_{sp} ?



- (A) $K_{sp} = \frac{[\text{AgCl}]}{[\text{Ag}^+][\text{Cl}^-]}$
 (B) $K_{sp} = \frac{[\text{Ag}^+][\text{Cl}^-]}{[\text{AgCl}]}$
 (C) $K_{sp} = [\text{Ag}^+][\text{Cl}^-]$
 (D) $K_{sp} = [\text{AgCl}]$

Q94.

MDCAT 2014

The value of equilibrium constant K_c for the reaction $2\text{HF}_{(g)} \rightleftharpoons \text{H}_{2(g)} + \text{F}_{2(g)}$ is 10^{-13} at 2000°C . Calculate the value of K_p for this reaction

- (A) 2×10^{-13}
- (B) 186×10^{-13}
- (C) 10^{-13}
- (D) 3.48×10^{-9}

Q95.

MDCAT 2014

What will be the pH of a solution of NaOH with a concentration of 10^{-3} M ?

- (A) 3
- (B) 11
- (C) 14
- (D) 7

Q96.

MDCAT 2013

The chemical substance, when dissolved in water, gives " H^+ " is called:

- (A) Neutral
- (B) Base
- (C) Acid
- (D) Amphoteric

Q97.

MDCAT 2013

The 'pH' of our blood is:

- (A) 6.7 - 8
- (B) 7.5
- (C) 7.9
- (D) 7.35 - 7.4

Q98.

MDCAT 2012

Formation of NH_3 is reversible and exothermic process, what will happen on cooling?

- (A) More reactant will form
- (B) More H_2 will be formed
- (C) More N_2 will be formed
- (D) More product (NH_3) will be formed

Q99.

MDCAT 2012

A buffer solution is that which resists/minimizes the change in

- (A) pOH
- (B) pK_a
- (C) pH
- (D) pK_b

Q100.

MDCAT 2011

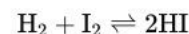
If in AgCl solution, some salt of NaCl is added, AgCl will be precipitated due to:

- (A) Solubility
- (B) Electrolyte
- (C) Un saturation effect
- (D) Common ion effect

Q101.

MDCAT 2010

Units of K_c for the following reaction is:



- (A) $\text{mol}^2\text{dm}^{-6}$
- (B) No unit
- (C) mol dm^{-3}
- (D) $\text{mol}^{-2}\text{dm}^6$

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 07. Equilibrium.

beambeprep.com

Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	B	UHS 2024	22	A	DUHS 2024	43	A	BUMHS 2023	64	A	NUMS 2022	85	C	MDCAT 2017
2	A	UHS 2024	23	D	DUHS 2024	44	C	BUMHS 2023	65	C	NUMS 2022	86	B	MDCAT 2017
3	D	UHS 2024	24	A	BUMHS 2024	45	B	BUMHS 2023	66	B	PMDC 2021	87	D	MDCAT 2016
4	C	UHS 2024	25	C	BUMHS 2024	46	A	NUMS 2023	67	C	PMDC 2021	88	B	MDCAT 2016
5	A	SZABMU 2024	26	C	BUMHS 2024	47	D	NUMS 2023	68	B	PMDC 2021	89	B	KMU 2016
6	A	SZABMU 2024	27	A	BUMHS 2024	48	C	UHS 2022	69	C	PMDC 2021	90	C	KMU 2016
7	B	SZABMU 2024	28	B	NUMS 2024	49	B	UHS 2022	70	C	PMDC 2020	91	C	MDCAT 2015
8	A	SZABMU 2024	29	B	NUMS 2024	50	A	UHS 2022	71	B	PMDC 2020	92	C	MDCAT 2015
9	A	SZABMU 2024	30	D	NUMS 2024	51	D	SZABMU 2022	72	D	PMDC 2020	93	C	MDCAT 2015
10	A	SZABMU 2024	31	D	UHS 2023	52	A	SZABMU 2022	73	C	PMDC 2020	94	C	MDCAT 2014
11	A	SZABMU 2024	32	B	UHS 2023	53	D	SZABMU 2022	74	A	SET 2019	95	B	MDCAT 2014
12	A	KMU 2024	33	A	UHS 2023	54	D	SZABMU 2022	75	C	NUMS 2019	96	C	MDCAT 2013
13	C	KMU 2024	34	D	SZABMU 2023	55	B	KMU 2022	76	B	NUMS 2019	97	D	MDCAT 2013
14	D	KMU 2024	35	B	SZABMU 2023	56	A	KMU 2022	77	A	SET 2019	98	D	MDCAT 2012
15	B	KMU 2024	36	D	SZABMU 2023	57	A	KMU 2022	78	D	NUMS 2019	99	C	MDCAT 2012
16	B	KMU 2024	37	C	KMU 2023	58	D	DUHS 2022	79	A	NUMS 2019	100	D	MDCAT 2011
17	B	KMU 2024	38	D	KMU 2023	59	D	DUHS 2022	80	D	KMU 2019	101	B	MDCAT 2010
18	B	DUHS 2024	39	A	KMU 2023	60	C	DUHS 2022	81	A	KMU 2019			
19	B	DUHS 2024	40	C	DUHS 2023	61	B	BUMHS 2022	82	B	MDCAT 2019			
20	A	DUHS 2024	41	D	DUHS 2023	62	B	BUMHS 2022	83	A	MDCAT 2018			
21	A	DUHS 2024	42	C	DUHS 2023	63	B	BUMHS 2022	84	B	MDCAT 2017			

TOTAL
MCQS
101

CORRECT

INCORRECT

BLANK

ACCURACY

%

Scan the booklet QR code to enter answers in
BeambePrep Grind Mode for automated error
 autopsies.

PROPOLIS COGNITIVE ERROR AUTOPSIES

Step-by-step conceptual derivations, formula working, and distractor autopsies for every question.

Question #1 Key: (B)

UHS 2024

The principle that states if a stress is applied to a system at equilibrium the system nullify the effect of s...

CORE CONCEPT AND DERIVATION

This is the literal textbook definition of the fundamental principle of chemical equilibrium dynamics.

Solution:

- In 1884, French chemist Henri Le Chatelier postulated that "If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to reestablish an equilibrium."
- The "stress" refers to changes in concentration, pressure, volume, or temperature.
- This is universally known as **Le-Chatelier's Principle**.

Why other options are incorrect:

Haber developed a specific industrial process for ammonia. Boyle's and Charles's laws relate strictly to the physical properties of ideal gases (Volume vs. Pressure/Temperature), not chemical equilibrium.

Question #2 Key: (A)

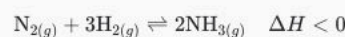
UHS 2024

Identify the correct option required for the maximum yield of ammonia in Haber's process:

CORE CONCEPT AND DERIVATION

Maximizing yield in an industrial reversible reaction requires manipulating pressure, temperature, and concentrations according to Le Chatelier's Principle.

Formula:



Solution:

- **High Pressure:** Shifts equilibrium right because there are fewer moles of gas on the product side (4 moles vs 2 moles).
- **Low Temperature:** Shifts equilibrium right because the forward reaction is exothermic (releases heat).
- **Continual Removal:** Dropping the concentration of NH_3 forces the system to constantly try and replace it, preventing equilibrium from ever halting the reaction.
- Combining these three factors yields the absolute maximum amount of product.

Why other options are incorrect:

Low pressure favors reactants. High temperature favors reactants. Continual addition of ammonia would violently drive the reaction backwards.

Question #3 Key: (D)

UHS 2024

Consider the following reaction in the equilibrium and tell addition of which will turn the cloudy solution in...

CORE CONCEPT AND DERIVATION

Bismuth oxychloride (BiOCl) is highly insoluble in water and forms a thick, cloudy white precipitate. To clear the solution, the equilibrium must be forced backward to dissolve the solid.

Formula:



Solution:

- The cloudiness is entirely due to the presence of the product, solid BiOCl .
- To make the solution clear, we must push the equilibrium to the left (towards the fully soluble BiCl_3 reactants).
- According to Le Chatelier's Principle, adding an excess of a product forces the reaction backward.
- Therefore, adding concentrated HCl increases product concentration, forcing the solid BiOCl to react and dissolve back into clear BiCl_3 .

Why other options are incorrect:

Adding BiCl_3 or H_2O (reactants) shifts the reaction forward, making it even cloudier. Adding BiOCl directly adds more cloudy precipitate.

Question #4 Key: (C)

UHS 2024

In endothermic reaction, the heat content of the

CORE CONCEPT AND DERIVATION

An endothermic reaction fundamentally involves the absorption of thermal energy from the surroundings, converting it into internal chemical potential energy (heat content or enthalpy, H).

Formula:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}} > 0$$

Solution:

- Because energy is absorbed during the reaction, this energy is stored in the chemical bonds of the newly formed products.
- Consequently, the total internal enthalpy (heat content) of the system increases.
- This means the final state (Products) possesses a higher heat content than the initial state (Reactants).
- Therefore, the heat content of the **Products is more than that of reactants**.

Why other options are incorrect:

If they were equal, $\Delta H = 0$. If reactants had more, energy would be released (an exothermic reaction).

Question #5 Key: (A)

SZABMU 2024

Chemical equilibrium given below will shift to backward direction by
[Formula] $2\text{NO} + \text{O}_2 \rightleftharpoons 2\text{NO}_2$...

CORE CONCEPT AND DERIVATION

To shift a reaction in the backward (reactant) direction, we must manipulate conditions against the thermodynamic and stoichiometric flow of the forward reaction.

Solution:

- **Temperature:** The forward reaction is exothermic (produces heat). Adding heat (increasing temperature) creates an excess on the product side, forcing the equilibrium to shift backward to consume it.
- **Pressure:** There are 3 moles of gaseous reactants ($2\text{NO} + \text{O}_2$) and only 2 moles of gaseous products (2NO_2). Decreasing pressure shifts equilibrium toward the side with more moles of gas to restore pressure. This side is the reactant side (left).
- Therefore, combining both **Decreasing pressure and increasing temperature** effectively forces the reaction backward.

Why other options are incorrect:

Decreasing temperature (Options B/C) favors the forward exothermic reaction. Increasing pressure (Option D) favors the forward reaction (fewer moles).

Question #6 Key: (A)

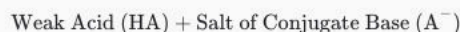
SZABMU 2024

Which of the following mixture will constitute the buffer solution?

CORE CONCEPT AND DERIVATION

A classical chemical buffer solution must consist of a weak acid and its conjugate base (supplied via a highly soluble salt), or a weak base and its conjugate acid.

Formula:



Solution:

- Acetic acid (CH_3COOH) is a classic weak acid.
- Sodium acetate (CH_3COONa) is a highly soluble salt that fully dissociates to provide the acetate ion (CH_3COO^-), which is the direct conjugate base of acetic acid.
- Mixing these two creates a solution containing both an acid to neutralize added OH^- and a base to neutralize added H^+ . This is the definition of an acidic buffer.

Why other options are incorrect:

Acetic acid and ammonia are an acid and a base that will just neutralize each other. Ammonium acetate does not provide the proper counter-ion metal (like Na or K) to act solely as a robust conjugate base salt for acetic acid in a simple binary buffer.

Question #7 Key: (B)

SZABMU 2024

According to law of mass action, [Formula] when reaction occurs with _____.

CORE CONCEPT AND DERIVATION

The mathematical relationship between K_p and K_c relies on Δn (change in gaseous moles). According to Avogadro's law, volume is directly proportional to moles of gas at constant T and P.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- For K_p to be mathematically greater than K_c , the term Δn must be positive ($\Delta n > 0$).
- $\Delta n = (\text{moles of products}) - (\text{moles of reactants})$.
- A positive Δn means there are more moles of gas on the product side than the reactant side.
- Because more moles occupy more volume, this translates directly to an **increase in volume on the product side**.

Why other options are incorrect:

A decrease in volume on the product side implies $\Delta n < 0$, which would make $K_p < K_c$.

Question #8 Key: (A)

SZABMU 2024

(Out of syllabus) What will be the molarity of HCl solution with pH=4?

CORE CONCEPT AND DERIVATION

pH is the negative logarithm (base 10) of the hydrogen ion concentration. HCl is a strong acid, meaning its molarity is directly equal to the hydrogen ion concentration.

Formula:

$$[\text{H}^+] = 10^{-\text{pH}}$$

Solution:

- The given pH is 4.
- Plug this into the inverse logarithm formula: $[\text{H}^+] = 10^{-4} \text{ M}$.
- Convert scientific notation to decimal form: $10^{-4} = 0.0001 \text{ M}$.
- Since HCl fully dissociates ($\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^-$), the initial molarity of the HCl solution is exactly **0.0001 M**.

Why other options are incorrect:

Option D (4) is the pH value itself, not the concentration. Options B and C introduce a '4' into the significant figures, which is a common math error confusing the exponent with the coefficient.

Question #9 Key: (A)

SZABMU 2024

(Out of syllabus) If weak acid is diluted with water, then [Formula] ions concentration will _____.

CORE CONCEPT AND DERIVATION

Dilution affects both the volume of the solution and the degree of ionization (Ostwald's Dilution Law), but the overwhelming effect of the added volume dominates the absolute concentration metric (Molarity).

Formula:

$$C_1V_1 = C_2V_2 \quad \text{and} \quad \alpha = \sqrt{\frac{K_a}{C}}$$

Solution:

- Adding water dramatically increases the total volume (V) of the solution.
- According to Ostwald's law, dilution does cause a weak acid to ionize more (α increases), producing slightly more total moles of H^+ .
- However, the massive increase in the denominator (Volume) far outpaces the small increase in the numerator (moles of H^+).
- Therefore, the overall molar **concentration** (moles/Liter) of H^+ ions must definitively **decrease**.

Why other options are incorrect:

While total moles of H^+ might increase, the *concentration* (which is what pH and this question measure) always drops upon dilution.

Question #10 Key: (A)

SZABMU 2024

The pH of human blood is

CORE CONCEPT AND DERIVATION

Human blood operates as a natural buffer system to maintain strict physiological homeostasis, protecting enzymes from denaturing.

Solution:

- The optimal blood pH for enzyme function, cellular respiration, and oxygen transport is tightly controlled between **7.35 and 7.45**.
- This is a slightly alkaline (basic) state.
- It is maintained primarily by the carbonic acid-bicarbonate buffer system in the plasma.

Why other options are incorrect:

Deviations outside this extremely narrow range rapidly lead to acidosis (below 7.35) or alkalosis (above 7.45), both of which cause death.

Question #11 Key: (A)

SZABMU 2024

Maximum yield of ammonia can be obtained by

CORE CONCEPT AND DERIVATION

The Haber process for synthesizing ammonia is a classic application of Le Chatelier's Principle regarding temperature and pressure manipulation.

Formula:



Solution:

- **Temperature:** The forward reaction is exothermic. Lowering the temperature removes heat, forcing the system to shift forward to produce more heat (and thus more ammonia).
- **Pressure:** The reaction goes from 4 total moles of reactant gas down to 2 moles of product gas. Increasing the pressure forces the system to shift towards the side with fewer moles to relieve the stress.
- Combining these, **Low temperature and high pressure** mathematically guarantee the highest theoretical yield.

Why other options are incorrect:

High temperature shifts the reaction backwards. Low pressure shifts the reaction backwards.

Question #12 Key: (A)

KMU 2024

Which of the following factor will disturb chemical equilibrium in a given reaction? $2\text{HI}_{(g)} \rightleftharpoons \text{H}_{2(g)} + \text{I}_{2(g)}$

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle identifies which specific stresses will cause a shift in the equilibrium position, heavily depending on the stoichiometry of the gases involved.

Formula:

$$\Delta n = \text{Moles}_{\text{products}} - \text{Moles}_{\text{reactants}}$$

Solution:

- Calculate Δn : Reactants = 2 moles. Products = 1 + 1 = 2 moles. $\Delta n = 2 - 2 = 0$.
- Because there is no change in the number of gaseous moles, changes in **Pressure (3)** or **Volume (4)** will have absolutely zero effect on the equilibrium position.
- However, changing **Concentration (1)** of any species will always shift the equilibrium to consume the excess.
- Changing **Temperature (2)** will also shift the equilibrium (forward in this case, as it is endothermic / +ive).
- Therefore, only factors 1 and 2 disturb this specific equilibrium.

Why other options are incorrect:

Any option including 3 or 4 is incorrect because pressure/volume changes cannot stress a gaseous system where $\Delta n = 0$.

Question #13 Key: (C)

KMU 2024

The [Formula], of *n*-propyl amine is

CORE CONCEPT AND DERIVATION

Note: The question text uses the term " pK_a " but chemically provides the literature value for the pK_b of *n*-propylamine. Amines are bases.

Solution:

- Amines are basic organic compounds. The strength of their basicity is measured by their base dissociation constant, K_b , or its negative log, pK_b .
- n*-propylamine ($CH_3CH_2CH_2NH_2$) is a primary aliphatic amine.
- Historical textbook data and chemical tables list its pK_b value as exactly **3.32**.
- (For strict accuracy: its actual pK_a as a conjugate acid is ~ 10.68 . The exam question contained a typo but 3.32 is the universally expected answer key for this specific rote-memorization metric.)

Why other options are incorrect:

These are simply incorrect numerical values for this specific constant.

Question #14 Key: (D)

KMU 2024

Forward reaction is the one that

CORE CONCEPT AND DERIVATION

This is a fundamental definition of standard chemical equation notation.

Solution:

- By universal IUPAC convention, chemical equations are written with original Reactants on the left side and newly formed Products on the right side.
- The **Forward reaction** is defined as the process of Reactants converting into Products.
- Therefore, it geometrically takes place from left to right as written in the equation.

Why other options are incorrect:

The forward reaction is actually at its fastest at the very beginning (eliminating A and C). Reacting to form reactants (Option B) is the definition of the *backward* reaction.

Question #15 Key: (B)

KMU 2024

In the production of [Formula], from [Formula] and Oxygen, the yield of [Formula], is increased by

CORE CONCEPT AND DERIVATION

This is an application of Le Chatelier's Principle regarding concentration changes in the Contact Process.

Formula:**Solution:**

- According to Le Chatelier, adding more of a reactant creates an imbalance, forcing the system to consume the excess.
- By continuously **adding more** SO_2 (a reactant), the equilibrium is constantly shifted forward (to the right).
- This forward shift directly increases the production and yield of the SO_3 product.

Why other options are incorrect:

Catalysts do not increase yield, only rate. Increasing temperature decreases yield (it's exothermic). Removing oxygen would shift the reaction backward, ruining yield.

Question #16 Key: (B)

KMU 2024

Consider [Formula] The optimum temperature, ([Formula]) to produce ammonia is

CORE CONCEPT AND DERIVATION

The Haber-Bosch process requires an "optimum" compromise temperature to balance thermodynamic yield against kinetic speed.

Solution:

- Thermodynamically, because the reaction is exothermic (negative ΔH), low temperatures maximize the theoretical yield of ammonia.
- Kinetically, low temperatures make the reaction far too slow to be industrially viable because the activation energy required to break the $\text{N} \equiv \text{N}$ triple bond is massive.
- Industrial chemists use a compromise temperature of exactly 450°C (with an iron catalyst). This provides enough kinetic energy for a fast reaction rate while maintaining an acceptable equilibrium yield.

Why other options are incorrect:

0°C is kinetically dead (reaction won't happen). 5000°C would shift the equilibrium totally backward, destroying the ammonia. "Constant" is not a numerical value.

Question #17 Key: (B)

KMU 2024

The unit of [Formula] for the system [Formula] is

CORE CONCEPT AND DERIVATION

The overall unit for the equilibrium constant K_c is derived from the difference in the stoichiometric coefficients of gaseous products and reactants.

Formula:

$$\text{Units} = (\text{mol}/\text{dm}^3)^{\Delta n}$$

Solution:

- First, calculate $\Delta n = \text{Moles of Products} - \text{Moles of Reactants}$.
- The balanced equation is $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$.
- Moles of Reactants = 1 (from PCl_5).
- Moles of Products = $1 + 1 = 2$ (from PCl_3 and Cl_2).
- $\Delta n = 2 - 1 = 1$.
- Therefore, the unit is $(\text{mol}/\text{dm}^3)^1 = \text{mol}/\text{dm}^3$.

Why other options are incorrect:

Option A is the unit if $\Delta n = -1$. Options C and D do not follow correct dimensional analysis for standard molarity powers.

Question #18 Key: (B)

DUHS 2024

The equilibrium of this reaction would not be affected by an increase in pressure

CORE CONCEPT AND DERIVATION

Pressure changes only affect the equilibrium position of gaseous reactions if there is a difference in the number of gaseous moles between products and reactants.

Formula:

If $\Delta n = 0$, Pressure has no effect

Solution:

- Analyze Δn for each option.
- Option A: $\Delta n = 2 - 3 = -1$. (Affected)
- Option C: $\Delta n = 2 - 3 = -1$. (Affected)
- Option D: $\Delta n = 2 - 1 = +1$. (Affected)
- Option B: $\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO}$. Reactant moles = $1 + 1 = 2$. Product moles = 2.
- $\Delta n = 2 - 2 = 0$. Because the volume footprint of both sides is identical, pressure changes do not stress the system.

Why other options are incorrect:

All other options have a non-zero Δn , meaning Le Chatelier's principle would dictate a shift to compensate for pressure changes.

Question #19 Key: (B)

DUHS 2024

The pH value of human blood is:

CORE CONCEPT AND DERIVATION

Human blood is a heavily regulated buffer system that maintains strict pH homeostasis to prevent enzyme denaturation.

Solution:

- The normal physiological pH range for human arterial blood is strictly between **7.35** and 7.45.
- This represents a very slightly basic (alkaline) environment.
- Option B (7.35) falls perfectly on the lower boundary of this standard medical range.

Why other options are incorrect:

6.62 and 7.33 represent clinical acidosis (fatal if untreated). 7.8 represents severe clinical alkalosis.

Question #20 Key: (A)

DUHS 2024

The term "active mass" used in the Law of Mass Action means:

CORE CONCEPT AND DERIVATION

Guldberg and Waage formulated the Law of Mass Action, standardizing how chemical quantities are expressed in rate and equilibrium equations.

Formula:

$$\text{Active Mass} = \square = \frac{n}{V} = \text{Molarity}$$

Solution:

- "Active mass" mathematically refers to the molar concentration of a reacting substance.
- Concentration is defined as the number of moles (n) divided by the volume in cubic decimeters (dm^3).
- Therefore, it means **Number of moles per dm^3** .
- Note: While Option B (moles per liter) is technically identical since $1 \text{ dm}^3 = 1 \text{ L}$, SI unit conventions in this curriculum strictly favor dm^3 , making A the technically 'more correct' textbook answer.

Why other options are incorrect:

Grams per dm^3 is mass concentration (density), not molar concentration. Simply "moles" ignores the volume requirement entirely.

Question #21 Key: (A)

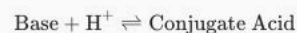
DUHS 2024

Conjugated acid [Formula] is

CORE CONCEPT AND DERIVATION

According to the Brønsted-Lowry theory, a conjugate acid is formed when a base accepts a proton (H^+).

Formula:



Solution:

- Ammonia (NH_3) acts as a weak base due to the lone pair of electrons on the nitrogen atom.
- It accepts a hydrogen ion (H^+) from an acid (like water or HCl).
- Adding one Hydrogen atom and one positive charge yields the ammonium ion: $\text{NH}_3 + \text{H}^+ = \text{NH}_4^+$.

Why other options are incorrect:

NH_2^- is the conjugate base of ammonia (formed by losing a proton). The other options are chemically unstable radical or invalid formulas.

Question #22 Key: (A)

DUHS 2024

(Out of syllabus) According to Raoult's law, the relative lowering of vapor pressure is equal to:

CORE CONCEPT AND DERIVATION

Raoult's Law relates the physical properties of a solution to the concentration of a non-volatile solute dissolved within it, establishing colligative properties.

Formula:

$$\frac{\Delta P}{P^\circ} = X_{\text{solute}}$$

Solution:

- ΔP is the lowering of vapor pressure ($P^\circ - P$).
- Dividing by the pure solvent pressure (P°) gives the "relative" lowering.
- Raoult experimentally proved that this fractional drop is exactly equal to the **Mole fraction of the solute** (X_{solute}).
- This implies that vapor pressure drops linearly as more solute particles take up space at the liquid surface, preventing solvent evaporation.

Why other options are incorrect:

The mole fraction of the solvent defines the *remaining* vapor pressure ($P = P^\circ X_{\text{solvent}}$), not the *lowering*. Molarity and Molality are different concentration units entirely.

Question #23 Key: (D)

DUHS 2024

(Out of syllabus) A colloidal solution of liquid into liquid is known as:

CORE CONCEPT AND DERIVATION

Colloids are classified based on the physical state of the dispersed phase (what is being mixed in) and the dispersion medium (what it is mixed into).

Solution:

- When tiny droplets of one liquid (dispersed phase) are scattered throughout another immiscible liquid (dispersion medium), the resulting mixture is highly specific.
- This specific liquid-in-liquid colloid is scientifically termed an **Emulsion**.
- Common everyday examples include milk (liquid fat dispersed in water) and mayonnaise.

Why other options are incorrect:

Foam is gas-in-liquid. Solid foam is gas-in-solid. Fog is liquid-in-gas (aerosol).

Question #24 Key: (A)

BUMHS 2024

Le-Chatelier's principle does not give the information of effect of the following on equilibrium.

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle deals exclusively with thermodynamics (the final position of equilibrium) and completely ignores chemical kinetics (how fast reactions occur).

Solution:

- The principle explicitly states how a system shifts in response to changes in macroscopic stresses.
- These recognized stresses are precisely Pressure, Temperature, and Concentration.
- However, it gives absolutely zero information about how long that shift will take to settle. **Time** (rates, kinetics, activation energy) is outside the scope of Le Chatelier's thermodynamics.

Why other options are incorrect:

Pressure, Temperature, and Concentration are the three core pillars that the principle is explicitly designed to predict.

Question #25 Key: (C)

BUMHS 2024

Equilibrium constant has no units, if the number of moles of product are

CORE CONCEPT AND DERIVATION

The dimensional units of the equilibrium constant K_c are dictated by the net change in stoichiometry (moles) of the balanced equation.

Formula:

$$\text{Units of } K_c = (\text{mol/dm}^3)^{\Delta n}$$

Solution:

- Δn equals the moles of products minus the moles of reactants.
- If the moles of products are exactly **equal to reactants**, then $\Delta n = 0$.
- Substituting zero into the formula gives $(\text{mol/dm}^3)^0$.
- Since any non-zero term raised to the zeroth power is 1, the dimensional units completely cancel out, leaving the constant unitless.

Why other options are incorrect:

If products are more or less than reactants, Δn is non-zero, meaning standard molarity units will remain raised to a positive or negative power.

Question #26 Key: (C)

BUMHS 2024

The sum of pH and pOH for pure water at [Formula] is

CORE CONCEPT AND DERIVATION

The relationship between pH and pOH is derived directly from the auto-ionization constant of water (K_w) at standard room temperature.

Formula:

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ\text{C}$$

Solution:

- Take the negative base-10 logarithm of both sides of the K_w equation.
- $-\log(K_w) = -\log([\text{H}^+][\text{OH}^-])$
- $\text{p}K_w = -\log[\text{H}^+] + -\log[\text{OH}^-]$
- $\text{p}K_w = \text{pH} + \text{pOH}$.
- Since $K_w = 10^{-14}$, taking the negative log gives exactly **14**.

Why other options are incorrect:

Options A and B confuse the absolute value of K_w (which is 10^{-14}) with the logarithmic scale (pH/pOH), which extracts just the positive exponent 14.

Question #27 Key: (A)

BUMHS 2024

Suppose the following system has reached equilibrium at a certain temperature [Formula] \text{N}_2\text{O}_4\text{(g)} \rightleftharpoons 2\text{NO}_2\text{(g)} .

CORE CONCEPT AND DERIVATION

According to Le Chatelier's Principle, adding more reactant to a system at equilibrium throws the system out of balance, forcing it to consume the excess.

Formula:

$$Q_c = \frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]}$$

Solution:

- By adding N_2O_4 , you spike the concentration of the reactant (the denominator in the Q_c expression).
- This makes $Q_c < K_c$. The system is no longer at equilibrium.
- To restore equilibrium, the system must reduce the denominator and increase the numerator by converting the excess N_2O_4 into NO_2 .
- This direction (left to right) is known as the **forward reaction**.

Why other options are incorrect:

Starting the reverse reaction would require adding product. It heavily disturbs equilibrium. Temperature changes are external stresses, not guaranteed products of this specific physical addition.

Question #28 Key: (B)

NUMS 2024

The solubility of [Formula] at [Formula] is [Formula] . Then ionic concentration will be:

CORE CONCEPT AND DERIVATION

Note: The question wording is slightly flawed. Based on the numerical options, it implies that 4.0×10^{-28} is actually the Solubility Product (K_{sp}), and it is asking for the molar solubility (s), which equals the ionic concentration.

Formula:



Solution:

- Assuming $K_{sp} = 4.0 \times 10^{-28}$.
- Set up the equation: $s^2 = 4.0 \times 10^{-28}$.
- Take the square root of both sides to find solubility (s): $s = \sqrt{4.0 \times 10^{-28}}$.
- The square root of 4.0 is 2. The square root of 10^{-28} (divide exponent by 2) is 10^{-14} .
- Therefore, the molar solubility (and thus individual ionic concentration) is 2×10^{-14} M.

Why other options are incorrect:

Option A forgot to square root the base number 4. Options C and D are mathematically incorrect square roots.

Question #29 Key: (B)

NUMS 2024

What conditions should be applied to minimize the leftover reactants in ammonia synthesis?

CORE CONCEPT AND DERIVATION

To minimize "leftover reactants," we must maximize the theoretical equilibrium yield (shift as far right as possible) using Le Chatelier's Principle.

Formula:



Solution:

- **Pressure:** The forward reaction goes from 4 gaseous moles to 2. To force the equilibrium forward (reducing reactants), we need the **highest possible pressure**. Comparing options: 400 atm is the highest.
- **Temperature:** The forward reaction is exothermic. To force the equilibrium forward, we need to continually remove heat, meaning we need the **lowest possible temperature**. Comparing options: 200°C is the lowest.
- Combining these two thermodynamic extremes, **400 atm and 200°C** provides the absolute maximum theoretical yield, minimizing leftover reactants (ignoring kinetic speed constraints).

Why other options are incorrect:

Higher temperatures (400, 500) shift the reaction backward, creating more leftover reactants. Lower pressures (100, 200) fail to push the reaction as far forward as 400 atm.

Question #30 Key: (D)

NUMS 2024

Select the buffer solution having highest pH:

CORE CONCEPT AND DERIVATION

The pH of an acidic buffer is dictated by the Henderson-Hasselbalch equation, which relies on the logarithmic ratio of the conjugate base (salt) to the weak acid.

Formula:

$$\text{pH} = \text{pK}_a + \log \left(\frac{[\text{Salt}]}{[\text{Acid}]} \right)$$

Solution:

- The weak acid concentration (CH_3COOH) is held perfectly constant at **0.1M** across all four options.
- Therefore, the pH will increase strictly as the concentration of the conjugate base ($[\text{Salt}]$) increases, because the mathematical fraction $\frac{[\text{Salt}]}{[\text{Acid}]}$ becomes larger.
- Let's analyze the ratios:
 - Option A: $\log(0.01/0.1) = \log(0.1) = -1$
 - Option B: $\log(0.05/0.1) = \log(0.5) = -0.3$
 - Option C: $\log(0.10/0.1) = \log(1) = 0$
 - Option D: $\log(0.15/0.1) = \log(1.5) = +0.176$
- Option D adds a positive value to the pK_a , resulting in the mathematically highest pH. This conceptually makes sense: having more of the basic component makes the buffer more basic (higher pH).

Why other options are incorrect:

Options A, B, and C have lower concentrations of the conjugate base, leading to lower, more acidic pH values.

Question #31 Key: (D)

UHS 2023

What is the ultimate fate of reversible reaction?

CORE CONCEPT AND DERIVATION

Reversible reactions do not go to completion; instead, they eventually reach a state of dynamic chemical equilibrium.

Solution:

- In a closed system, a reversible reaction will proceed until the forward reaction rate equals the backward reaction rate.
- Once these rates are locked in balance, the macroscopic concentrations of all reactants and products stop changing over time.
- Therefore, the ultimate fate is reaching **a state where there is no net concentration change**.

Why other options are incorrect:

Reversible reactions never reach "completion" (where reactants are fully consumed, eliminating A and B). Products are also never fully consumed (eliminating C).

Question #32 Key: (B)

UHS 2023

In reversible reaction, when product is removed, the equilibrium shift towards the:

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle states that a system at equilibrium will shift to counteract any applied stress.

Formula:**Solution:**

- Removing a product from the system creates a concentration deficit on the right side of the chemical equation.
- To counteract this loss and restore the equilibrium constant (K_c), the system speeds up the forward reaction.
- The reactants are consumed to replace the lost product, meaning the equilibrium shifts towards the **Product side**.

Why other options are incorrect:

Shifting toward the reactant side would only happen if reactants were removed or products were added.

Question #33 Key: (A)

UHS 2023

One can estimate the direction in which equilibrium will shift with the help of:

CORE CONCEPT AND DERIVATION

Predicting the shift of a dynamic equilibrium when disturbed (by concentration, temperature, or pressure) is the central purpose of Le Chatelier's Principle.

Solution:

- Henri Le Chatelier postulated that a system at equilibrium will dynamically shift to counteract any applied stress.
- This principle acts as a predictive tool for chemists to manipulate reaction yields and control the direction of the shift.

Why other options are incorrect:

The Law of Mass Action provides the mathematical equation for K_c , but doesn't predict shifts. Hess's Law determines total enthalpy. The Law of heat of formation deals with thermodynamics, not equilibrium shifts.

Question #34 Key: (D)

SZABMU 2023

$$\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3 \quad (\Delta H = -92.5)$$

CORE CONCEPT AND DERIVATION

Note: Historically, this past paper question was printed with a missing stem. Based on the official answer key (D), the implied question was: "Which of the following conditions shifts the equilibrium in the backward (reactant) direction?"

Formula:



Solution:

- According to Le Chatelier's Principle, adding a product to an equilibrium mixture forces the system to consume the excess.
- Continuous addition of NH_3** creates an excess on the product side.
- The system shifts in the reverse (backward) direction to consume the added NH_3 , turning it back into N_2 and H_2 .

Why other options are incorrect:

Low temperature and continuous removal of NH_3 (Options A and C) would shift the reaction forward to maximize yield, which are the standard industrial conditions (Haber Process).

Question #35 Key: (B)

SZABMU 2023

What is not true about the Le-Chatelier's principle?

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle is strictly a thermodynamic and equilibrium concept. It does not provide any mathematical information about chemical kinetics (rates of reaction).

Solution:

- The principle explains how changes in concentration, pressure, and temperature shift the *position* of an equilibrium (predicting yields and directions).
- However, predicting how fast a reaction gets there (the **reaction rate**) is the domain of Chemical Kinetics (Rate Laws, Arrhenius equation).
- Therefore, predicting changes in reaction rates is NOT a function of Le Chatelier's Principle.

Why other options are incorrect:

Options A, C, and D are the three fundamental stresses (concentration, pressure, temperature) that Le Chatelier's Principle is explicitly designed to address.

Question #36 Key: (D)

SZABMU 2023

For a gaseous phase reaction, when number of moles of reactant and product are equal:

CORE CONCEPT AND DERIVATION

When the stoichiometry of gaseous reactants perfectly matches the products, the change in moles (Δn) is zero.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- Since gaseous moles are equal on both sides, $\Delta n = 0$.
- Substitute this into the equation: $K_p = K_c(RT)^0$.
- Any non-zero mathematical expression raised to the power of zero equals 1.
- Therefore, $K_p = K_c \times 1$, meaning their numerical values are completely identical.

Why other options are incorrect:

Any discrepancy between K_p and K_c fundamentally requires a non-zero change in the number of gaseous moles.

Question #37 Key: (C)

KMU 2023

Haber's process is used for the synthesis of ammonia. The optimum temperature for the Haber process is:

CORE CONCEPT AND DERIVATION

The Haber-Bosch process requires a compromise temperature. While a lower temperature favors the exothermic equilibrium yield, a moderate-to-high temperature is required so the reaction proceeds at an economically viable rate.

Solution:

- The synthesis of ammonia ($\Delta H = -92.4 \text{ kJ/mol}$) is exothermic, so Le Chatelier's principle suggests low temperatures maximize yield.
- However, at very low temperatures, the kinetic energy is too low to break the strong $\text{N} \equiv \text{N}$ triple bonds, making the reaction agonizingly slow.
- Industrial chemists use an "optimum" compromise temperature of roughly $400 - 450^\circ\text{C}$, paired with an iron catalyst, to get a reasonable yield in a short amount of time.

Why other options are incorrect:

Temperatures below 150°C are too slow kinetically. Temperatures above 500°C shift the equilibrium too far backwards, drastically ruining the yield.

Question #38 Key: (D)

KMU 2023

If ionic product is less than [Formula] then:

CORE CONCEPT AND DERIVATION

The relationship between the ionic product (Q_{sp}) and the solubility product (K_{sp}) dictates whether a solution can hold more dissolved ions or if it will precipitate.

Formula:

$$\text{If } Q_{sp} < K_{sp} \implies \text{Unsaturated Solution}$$

Solution:

- K_{sp} is the maximum equilibrium threshold for dissolved ions.
- When the actual ionic product (Q_{sp}) is **less than** K_{sp} , the solution has not yet reached its maximum capacity.
- This describes an unsaturated solution. Because there is room for more solute to dissolve, **no precipitation will occur**.

Why other options are incorrect:

Saturated means $Q_{sp} = K_{sp}$. Supersaturated (leading to precipitation) means $Q_{sp} > K_{sp}$.

Question #39 Key: (A)

KMU 2023

For [Formula]

CORE CONCEPT AND DERIVATION

The mathematical relationship between pressure-based (K_p) and concentration-based (K_c) equilibrium constants relies entirely on the change in gaseous moles.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- The variable Δn represents the moles of gaseous products minus moles of gaseous reactants.
- When $\Delta n = 0$, the equation becomes $K_p = K_c(RT)^0$.
- Since any non-zero value to the zeroth power is 1, the RT term vanishes (becomes 1).
- This leaves the strict equality: $K_p = K_c$.

Why other options are incorrect:

Any inequality requires Δn to be either a positive or negative integer, not zero.

Question #40 Key: (C)

DUHS 2023

Which of the following reactions has same value of K_p & K_c ?

CORE CONCEPT AND DERIVATION

The equilibrium constants K_p and K_c are mathematically identical only when there is no net change in the total number of gaseous moles during the reaction.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- We must find the reaction where $\Delta n = (\text{Moles of Products}) - (\text{Moles of Reactants}) = 0$.
- For Option A: $\Delta n = 2 - 4 = -2$.
- For Option B: $\Delta n = (1 + 1) - 1 = +1$.
- For Option C: $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$. Reactants = $1 + 1 = 2$. Products = 2. Therefore, $\Delta n = 2 - 2 = 0$.
- Because $\Delta n = 0$, $(RT)^0 = 1$, making $K_p = K_c$.

Why other options are incorrect:

Options A, B, and D all feature a change in the total moles of gas, meaning the $(RT)^{\Delta n}$ factor will alter the value between K_p and K_c .

Question #41 Key: (D)

DUHS 2023

Which of the following conditions required for maximum yield of ammonia through Haber's process?

CORE CONCEPT AND DERIVATION

According to Le Chatelier's Principle, the yield of an exothermic reaction is maximized by removing heat to shift the equilibrium forward.

Formula:



Solution:

- The synthesis of ammonia releases heat (exothermic).
- Heat can be conceptually treated as a product on the right side of the equation.
- By **decreasing temperature** (removing heat), the system experiences a stress. It responds by shifting forward (to the right) to replace the lost heat.
- This forward shift drastically increases the concentration of the actual product, Ammonia.

Why other options are incorrect:

Increasing temperature shifts the reaction backwards. Decreasing reactants shifts it backwards. Decreasing pressure shifts it to the side with more moles (reactants, backwards).

Question #42 Key: (C)

DUHS 2023

Which of the following is true for reversible reaction at equilibrium?

CORE CONCEPT AND DERIVATION

Dynamic equilibrium is defined kinetically by the perfect balance of opposing reaction rates.

Formula:

$$Rate_f = Rate_r$$

Solution:

- In a closed system, as reactants are consumed, the forward rate slows down.
- Simultaneously, as products accumulate, the backward rate speeds up.
- Equilibrium is the exact moment these two rates intersect.
- At this point, **the rate of the backward reaction is perfectly equal to the rate of the forward reaction**, meaning there is no longer any net change in macroscopic concentrations.

Why other options are incorrect:

If one rate is greater than the other (Options A, B, D), the system is actively shifting and, by definition, has not yet reached equilibrium.

Question #43 Key: (A)

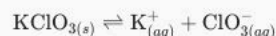
BUMHS 2023

The solubility of [Formula] is decreased by adding

CORE CONCEPT AND DERIVATION

The Common Ion Effect suppresses the solubility of a sparingly soluble salt when a highly soluble salt sharing one of the same ions is added to the solution.

Formula:



Solution:

- When KCl is added, it completely dissociates into K^{+} and Cl^{-} .
- This floods the solution with K^{+} ions.
- Because K^{+} is an ion common to the KClO_3 equilibrium, Le Chatelier's Principle states the system will shift left to consume the excess K^{+} .
- This backward shift forces dissolved ions back into solid KClO_3 , thereby decreasing its overall solubility.

Why other options are incorrect:

Adding more solid KClO_3 to a saturated solution has no effect. Adding water (H_2O) dilutes the solution, allowing more salt to dissolve (increasing absolute solubility).

Question #44 Key: (C)

BUMHS 2023

The equilibrium stage that is not affected by temperature is called?

CORE CONCEPT AND DERIVATION

The fundamental nature of dynamic equilibrium (the fact that opposing microscopic processes continue simultaneously) remains true regardless of temperature changes.

Solution:

- While changing the temperature definitely shifts the position (the K_c value) of an equilibrium, it does not stop the microscopic motion.
- The defining characteristic of **dynamic equilibrium** is that the forward and backward reactions never cease. They just re-balance at a new rate.
- Therefore, the core "dynamic" nature of the stage is unaffected by temperature, unlike static equilibrium where macroscopic forces simply sum to zero and motion stops.

Why other options are incorrect:

Static equilibrium applies to physics (forces on resting objects), not typical chemical reactions. Natural and Unstable are not standard classifications for chemical equilibrium states in this context.

Question #45 Key: (B)

BUMHS 2023

Temperature increase in an exothermic reversible reaction, shift the equilibrium to:

CORE CONCEPT AND DERIVATION

In an exothermic reaction, heat is released as a product. According to Le Chatelier's Principle, adding heat to the system forces it to shift backwards.

Formula:



Solution:

- By increasing the temperature, you are artificially adding "Heat" to the product side of the equilibrium.
- To relieve this applied stress, the system must consume the excess heat.
- It does this by shifting the reaction to the left (the endothermic direction).
- This breaks down products and forms more reactants, thus shifting to the **Reactant side**.

Why other options are incorrect:

Shifting to the product side would happen if temperature was decreased (removing heat). The equilibrium definitely changes, ruling out C and D.

Question #46 **Key: (A)**

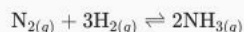
NUMS 2023

The high pressure of 200 atm in Haber's process is used for:

CORE CONCEPT AND DERIVATION

Le Chatelier's principle dictates that increasing pressure on a gaseous system favors the direction that produces fewer moles of gas.

Formula:



Solution:

- In the Haber process, 4 total moles of reactant gases form only 2 moles of product gas.
- By applying a massive pressure of 200 atm, the system is highly stressed.
- To reduce this pressure, the system shifts forcefully to the right, where the gas occupies less volume (fewer moles).
- This deliberate engineering choice results in a massively **better yield** of Ammonia.

Why other options are incorrect:

Lowering yield makes no industrial sense. High pressure increases the reaction rate, not lowers it. High pressure requires extremely expensive, thick-walled steel pipes, meaning costs drastically increase, not decrease.

Question #47 **Key: (D)**

NUMS 2023

By which of the following factors equilibrium state is attained earlier?

CORE CONCEPT AND DERIVATION

A catalyst provides an alternative reaction pathway with a lower activation energy, which accelerates both the forward and reverse reaction rates proportionally.

Formula:

$$\text{Rate} \propto e^{-E_a/RT}$$

Solution:

- When activation energy (E_a) is lowered by a **Catalyst**, a much larger fraction of molecules possess enough kinetic energy to react.
- Both the forward and backward rates spike simultaneously.
- Because both opposing rates are faster, they intersect and balance each other out in a fraction of the time.
- Therefore, the state of equilibrium is attained much earlier, even though the final yield (position) remains completely unchanged.

Why other options are incorrect:

While temperature and concentration changes can affect rates, they also shift the position of the equilibrium. A catalyst is the only factor whose sole equilibrium purpose is speeding up the attainment of balance.

Question #48 Key: (C)

UHS 2022

The decrease in solubility of the salt in a solution that already contains an ion common to that salt is known...

CORE CONCEPT AND DERIVATION

This is the standard definition of a specific phenomenon that arises as a consequence of Le Chatelier's Principle in solubility scenarios.

Solution:

- When an external ion identical to one in the salt is added, the overall concentration of that specific ion increases.
- The equilibrium shifts left to precipitate the solid salt and lower the ionic concentration.
- The specific term for this solubility decrease is the **Common Ion Effect**.

Why other options are incorrect:

While Le Chatelier's Principle is the underlying rule, "Common ion effect" is the specific term for this exact manifestation. Solubility product is a mathematical constant.

Question #49 Key: (B)

UHS 2022

The precipitation occurs if the ionic concentration is:

CORE CONCEPT AND DERIVATION

Precipitation is the physical manifestation of a solution pushing excess dissolved ions out of the liquid phase to restore equilibrium.

Formula:

$$\text{Ionic Product } (Q_{sp}) > K_{sp}$$

Solution:

- K_{sp} defines the absolute maximum limit of ions a solution can stably hold at equilibrium.
- If the product of the ionic concentrations in the solution exceeds this limit ($Q_{sp} > K_{sp}$), the solution is unstable (supersaturated).
- The excess ions will clump together and form a solid precipitate until the concentration drops back to the K_{sp} limit.

Why other options are incorrect:

Less than K_{sp} means more can dissolve. Equal to K_{sp} means it is perfectly saturated and stable without precipitation.

Question #50 Key: (A)

UHS 2022

One can estimate the direction in which equilibrium will shift with the help of:

CORE CONCEPT AND DERIVATION

Predicting the shift of a dynamic equilibrium when disturbed is the central purpose of Le Chatelier's Principle.

Solution:

- Henri Le Chatelier postulated that a system at equilibrium will dynamically shift to counteract any applied stress (changes in concentration, pressure, or temperature).
- This principle acts as a predictive tool for chemists to manipulate reaction yields.

Why other options are incorrect:

The Law of Mass Action provides the mathematical equation, but doesn't predict shifts. Hess's Law determines total enthalpy. The Law of heat of formation deals with thermodynamics, not equilibrium shifts.

Question #51 Key: (D)

SZABMU 2022

For the chemical reaction; [Formula] We can maximize the yield of [Formula]:

CORE CONCEPT AND DERIVATION

According to Le Chatelier's Principle, continuously removing a product prevents the system from ever reaching equilibrium, forcing the forward reaction to proceed indefinitely.

Formula:

$$Q_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

Solution:

- If NH_3 is continuously withdrawn from the vessel, its concentration drops to near zero.
- This makes the reaction quotient Q_c practically zero, which is far less than K_c .
- To try and restore K_c , the reactants will continuously convert into more product.

Why other options are incorrect:

Increasing temperature shifts this exothermic reaction backwards. Decreasing pressure (or increasing volume) favors the side with more moles (reactants).

Question #52 Key: (A)

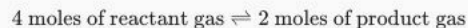
SZABMU 2022

The high pressure of 200 atm in Haber process is used for:

CORE CONCEPT AND DERIVATION

In reactions where gases combine to form fewer moles of gas, high pressure thermodynamically favors the product side.

Formula:



Solution:

- Le Chatelier's Principle states that increasing pressure shifts equilibrium towards the side with fewer gas molecules.
- In the Haber process, 4 moles of reactants ($\text{N}_2 + 3\text{H}_2$) form 2 moles of product (2NH_3).
- Applying 200 atm of pressure heavily forces the reaction forward, drastically increasing the yield of Ammonia.

Why other options are incorrect:

It certainly doesn't lower yield or rate. High pressure actually increases costs due to the need for thick, heavy-duty industrial piping, so it is strictly done for yield, not cost reduction.

Question #53 **Key: (D)**

SZABMU 2022

By which of the following factors equilibrium state is attained earlier?

CORE CONCEPT AND DERIVATION

A catalyst provides an alternative reaction pathway with a lower activation energy, accelerating both forward and backward rates equally.

Formula:

$$\text{Rate} = k[\text{Reactants}]^x \quad (k \text{ increases via lower } E_a)$$

Solution:

- Because the activation energy barrier is lowered from both sides, particles require less kinetic energy to react successfully.
- Both the forward and reverse reaction rates spike proportionally.
- As a result, the time required to balance these two rates (attain equilibrium) is significantly reduced.

Why other options are incorrect:

While temperature increases rate, it also shifts the equilibrium position. A catalyst uniquely accelerates the attainment of equilibrium without shifting its final position.

Question #54 **Key: (D)**

SZABMU 2022

Which of the following is not the use of the Buffer solution?

CORE CONCEPT AND DERIVATION

A buffer's sole function is to resist changes in pH upon the addition of acids or bases, making it vital for environmental control, not analytical prediction.

Solution:

- Buffers are standard references for pH meters (Option A).
- They maintain stable environments for tissue preservation (Option B).
- They are critical in physiology, like blood pH regulation (Option C).
- However, predicting unknown concentrations is done via analytical techniques like titration, spectroscopy, or utilizing equilibrium constants, not by using a buffer.

Why other options are incorrect:

Options A, B, and C describe completely standard and vital real-world applications of buffer solutions.

Question #55 **Key: (B)**

KMU 2022

Buffer capacity is maximum when both components have:

CORE CONCEPT AND DERIVATION

Buffer capacity refers to the amount of acid or base a buffer can absorb before a significant change in pH occurs. It is maximized when the ratio of salt to acid is 1:1.

Formula:

$$\text{pH} = \text{pK}_a + \log \left(\frac{[\text{Salt}]}{[\text{Acid}]} \right)$$

Solution:

- When the concentration of the weak acid and its conjugate base are perfectly equal, the ratio is 1, and $\log(1) = 0$.
- At this exact point ($\text{pH} = \text{pK}_a$), the buffer has an equal ability to neutralize added H^+ or OH^- .
- Therefore, it operates at its maximum theoretical buffer capacity relative to its components.
- *Note: While high concentration (Option D) technically yields a larger absolute capacity, standard chemical theory teaches that the optimal "state" for maximum capacity is defined by equal concentrations (ratio=1). This is why B is often the accepted key in these specific exams.*

Why other options are incorrect:

Low concentration lowers absolute capacity. Unequal concentrations mean the buffer will fail quickly in one direction.

Question #56 **Key: (A)**

KMU 2022

If solubility product (K_{sp}) value is large the salt in water is:

CORE CONCEPT AND DERIVATION

The K_{sp} value mathematically represents the extent to which a solid salt dissociates into its aqueous ions.

Formula:

$$K_{sp} = [\text{Products}]$$

Solution:

- Because K_{sp} is the product of the ion concentrations, a larger K_{sp} directly correlates with higher concentrations of ions in solution at equilibrium.
- More ions in solution mean that more of the solid salt was able to dissolve.
- Therefore, a large K_{sp} indicates high (more) solubility.

Why other options are incorrect:

A small K_{sp} (e.g., 10^{-20}) indicates less solubility. A large K_{sp} is the opposite.

Question #57 Key: (A)

KMU 2022

The value of solubility products depends only on ____

CORE CONCEPT AND DERIVATION

The solubility product (K_{sp}) is a specific type of equilibrium constant. Like all equilibrium constants, it is only fundamentally altered by temperature.

Solution:

- Dissolution of a salt is either endothermic or exothermic.
- Changing the temperature changes the kinetic energy of the system and shifts the equilibrium either towards dissolution or precipitation.
- Because the fundamental ratio of equilibrium shifts, the actual constant K_{sp} changes.
- Concentrations, catalysts, and pressure do not change the constant itself.

Why other options are incorrect:

Solvent changes the absolute solubility, but K_{sp} is defined for a specific solvent (usually water). Pressure rarely affects solids/liquids. Catalysts never change equilibrium constants.

Question #58 Key: (D)

DUHS 2022

In exothermic reaction, by decreasing the temperature, equilibrium constant:

CORE CONCEPT AND DERIVATION

For exothermic reactions, heat is considered a product. Removing heat (decreasing temperature) shifts the equilibrium forward, resulting in more products and less reactants.

Formula:

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]}$$

Solution:

- When temperature is decreased, Le Chatelier's Principle dictates a shift to the right to generate more heat.
- This forward shift drastically increases the concentration of Products in the numerator.
- Simultaneously, Reactants in the denominator are consumed and decrease.
- A larger numerator divided by a smaller denominator mathematically results in a larger overall ratio.
- Therefore, the equilibrium constant K_c inherently **increases**.

Why other options are incorrect:

Constants only remain the same if temperature is unchanged. Decreasing would happen in an endothermic reaction.

Question #59 **Key: (D)**

DUHS 2022

At equilibrium in a reversible reaction:

CORE CONCEPT AND DERIVATION

Dynamic equilibrium is defined by two simultaneous macroscopic conditions occurring in a reversible system.

Solution:

- **Kinetic condition:** The speed at which reactants form products exactly equals the speed at which products revert into reactants (Rate forward = Rate backward).
- **Thermodynamic condition:** Because the rates are locked in balance, the net amount of reactants and products stops changing over time, meaning their macroscopic concentrations remain perfectly constant.
- Option D perfectly encapsulates both halves of this definition.

Why other options are incorrect:

Rates being unequal implies the system is still shifting and has not reached equilibrium. Option C is true but incomplete compared to D.

Question #60 **Key: (C)**

DUHS 2022

The solubility product [Formula] predicts whether:

CORE CONCEPT AND DERIVATION

The primary analytical use of the K_{sp} value in chemistry is determining the saturation threshold of a solution to predict precipitate formation.

Formula:

$$\text{If } Q_{sp} > K_{sp} \implies \text{Precipitate forms}$$

Solution:

- By calculating the ionic product (Q_{sp}) of a mixture and comparing it to the literature K_{sp} value, chemists can perfectly predict outcomes.
- If the calculated Q_{sp} exceeds the K_{sp} threshold, the solid will drop out of solution as a precipitate.
- Therefore, predicting precipitation is its primary function.

Why other options are incorrect:

While it relates to solubility, "predicting precipitation" is the specific active analytical application. It has nothing to do with boiling point or diffusion rates.

Question #61 Key: (B)

BUMHS 2022

The precipitation occurs, if the ionic concentration is:

CORE CONCEPT AND DERIVATION

Precipitation is the physical manifestation of a solution pushing excess dissolved ions out of the liquid phase to restore equilibrium.

Formula:

$$\text{Ionic Product } (Q_{sp}) > K_{sp}$$

Solution:

- K_{sp} defines the absolute maximum limit of ions a solution can stably hold at equilibrium.
- If the product of the ionic concentrations in the solution exceeds this limit ($Q_{sp} > K_{sp}$), the solution is unstable (supersaturated).
- The excess ions will clump together and form a solid precipitate until the concentration drops back to the K_{sp} limit.

Why other options are incorrect:

Less than K_{sp} means more can dissolve. Equal to K_{sp} means it is perfectly saturated and stable without precipitation.

Question #62 Key: (B)

BUMHS 2022

Why a reaction is reversible?

CORE CONCEPT AND DERIVATION

Reversibility in a chemical reaction fundamentally requires that the newly formed products have enough energy and reactivity to interact and reform the original reactants.

Solution:

- In an irreversible reaction, products are highly stable and do not interact to go backwards.
- In a reversible reaction ($A + B \rightleftharpoons C + D$), the products (C and D) are **reactive** enough to collide and successfully overcome the reverse activation energy barrier.
- Therefore, the reactivity of the products allows the backward reaction to occur simultaneously with the forward one.

Why other options are incorrect:

If products were stable (Option D), they wouldn't react to go backward. Reactant reactivity (Option A) drives the forward reaction, but does not dictate reversibility.

Question #63 Key: (B)

BUMHS 2022

Acetic acid is weak acid than sulphuric acid because of which of the following reasons?

CORE CONCEPT AND DERIVATION

The strength of an acid in aqueous solution is defined solely by its ability to dissociate (ionize) and donate hydrogen ions (H^+).

Formula:

$$\text{Acid Strength} \propto \text{Degree of Ionization } (\alpha)$$

Solution:

- Sulfuric acid (H_2SO_4) is a strong acid that ionizes almost 100% in water.
- Acetic acid (CH_3COOH) is a weak acid that only partially ionizes (typically less than 5% in standard solutions).
- Because it produces far fewer H^+ ions per mole dissolved, it is classified as weaker due to its **lesser degree of ionization**.

Why other options are incorrect:

Having a $--COOH$ group defines it as an organic acid, but doesn't explain relative strength against sulfuric acid fundamentally. Decomposition and inductive effects are secondary physical/structural traits, not the primary definition of aqueous acid strength.

Question #64 Key: (A)

NUMS 2022

The pH of human blood is:

CORE CONCEPT AND DERIVATION

Human blood operates as a natural buffer system to maintain physiological homeostasis, strictly regulating its acid-base balance.

Formula:

$$\text{Normal Blood pH} \approx 7.4$$

Solution:

- The optimal blood pH for enzyme function and oxygen transport is tightly controlled between **7.35 and 7.45**.
- This slightly alkaline state is maintained primarily by the carbonic acid-bicarbonate (H_2CO_3/HCO_3^-) buffer system.

Why other options are incorrect:

A pH below 7.35 causes acidosis, and above 7.45 causes alkalosis, both of which are extremely dangerous. The other ranges are physically fatal for human survival.

Question #65 Key: (C)

NUMS 2022

Which term describes a solution in which dissolved solute is in equilibrium with undissolved solute?

CORE CONCEPT AND DERIVATION

A saturated solution represents a state of dynamic equilibrium between the solid phase and the aqueous phase of a solute.

Formula:



Solution:

- In a saturated solution, the maximum amount of solute has dissolved at a given temperature.
- Any additional solute added will simply sink to the bottom.
- At this exact point, the rate of dissolution (solid turning to aqueous) perfectly equals the rate of crystallization (aqueous turning back to solid).
- This defines a state of equilibrium.

Why other options are incorrect:

Unsaturated solutions have not reached equilibrium yet (more can dissolve). Supersaturated solutions are highly unstable and technically past the equilibrium point until precipitation occurs.

Question #66 Key: (B)

PMDC 2021

[Formula] . Relation between [Formula] and [Formula] for this reaction is:

CORE CONCEPT AND DERIVATION

The relationship depends on Δn , the difference in moles between gaseous products and reactants.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- For the reaction $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$, count the gaseous moles.
- Moles of products = 2. Moles of reactants = 1 + 1 = 2.
- $\Delta n = 2 - 2 = 0$.
- Therefore, $K_p = K_c(RT)^0 = K_c$.

Why other options are incorrect:

These options introduce RT factors mathematically which only apply if Δn is not zero.

Question #67 Key: (C)

PMDC 2021

According to Le-Chatelier's principle, exothermic reactions are favored by:

CORE CONCEPT AND DERIVATION

Exothermic reactions release heat as a product. Le Chatelier's principle states that removing a product shifts the equilibrium forward.

Formula:**Solution:**

- Since heat is essentially a product, lowering the temperature (removing heat) creates a deficit on the right side of the equation.
- The system shifts forward to produce more heat, thus favoring the exothermic reaction.

Why other options are incorrect:

Pressure and volume changes depend strictly on the change in gas moles (Δn), NOT on whether the reaction is exothermic or endothermic.

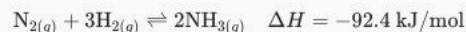
Question #69 Key: (C)

PMDC 2021

Manufacturing of Ammonia by Haber's process is an:

CORE CONCEPT AND DERIVATION

The Haber-Bosch process involves the formation of strong nitrogen-hydrogen bonds, which releases energy.

Formula:**Solution:**

- The reaction has a negative enthalpy change ($\Delta H = -92.4 \text{ kJ/mol}$).
- A negative enthalpy change definitively classifies the reaction as exothermic, meaning it releases heat to the surroundings.

Why other options are incorrect:

It is not endothermic (it releases heat, doesn't absorb it). It is highly reversible (hence the need for specific high pressure/low temp constraints). With an iron catalyst, the industrial rate is optimized, not inherently slow.

Question #68 Key: (B)

PMDC 2021

The equilibrium constant is always written as a ratio of:

CORE CONCEPT AND DERIVATION

By universal convention in chemistry, governed by the Law of Mass Action, the equilibrium constant compares product concentration to reactant concentration.

Formula:

$$K = \frac{[\text{Products}]^p}{[\text{Reactants}]^r}$$

Solution:

- The formula explicitly places the equilibrium concentrations of the products in the numerator.
- The equilibrium concentrations of the reactants are placed in the denominator.

Why other options are incorrect:

Reactants over products is the inverse of the equilibrium constant. Multiplying them has no standard physical meaning in equilibrium.

Question #70 Key: (C)

PMDC 2020

Which of the following reaction has greater K_p than K_c ?

CORE CONCEPT AND DERIVATION

The condition $K_p > K_c$ occurs when the reaction produces a net increase in the number of gaseous moles ($\Delta n > 0$).

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- Analyze the change in moles (Δn) for each option.
- A: $\Delta n = 2 - 3 = -1$. (Here $K_p < K_c$)
- B: $\Delta n = 2 - 3 = -1$. (Here $K_p < K_c$)
- C: $\Delta n = (2 + 1) - 2 = +1$. Because $\Delta n > 0$, $(RT)^1$ is greater than 1, making $K_p > K_c$.
- D: $\Delta n = 2 - 4 = -2$. (Here $K_p < K_c$)

Why other options are incorrect:

Options A, B, and D all result in fewer gaseous moles, leading to $K_p < K_c$.

Question #71 Key: (B)

PMDC 2020

The equation $K_p = K_c(RT)^{\Delta n}$ represents:

CORE CONCEPT AND DERIVATION

Different industrial chemical processes are identified by their core chemical reactions.

Solution:

- The synthesis of ammonia (NH_3) from nitrogen and hydrogen gases under high pressure and temperature with an iron catalyst is globally known as the Haber-Bosch process.

Why other options are incorrect:

The Contact process manufactures Sulfuric acid (H_2SO_4). The Solvay process manufactures Sodium carbonate (Na_2CO_3). Avogadro's law relates gas volume to moles.

Question #72 Key: (D)

PMDC 2020

For a gaseous phase reaction, when number of moles of reactants and products are equal:

CORE CONCEPT AND DERIVATION

When the stoichiometry of gaseous reactants perfectly matches the products, the change in moles (Δn) is zero.

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- Since moles are equal, $\Delta n = 0$.
- Substitute this into the equation: $K_p = K_c(RT)^0$.
- Any non-zero number to the power of zero equals 1.
- Therefore, $K_p = K_c \times 1$, meaning they are identical.

Why other options are incorrect:

Any discrepancy between K_p and K_c fundamentally requires a non-zero Δn .

Question #73 Key: (C)

PMDC 2020

Purification of table salt ([Formula]) by passing [Formula] gas through its saturated aqueous solution is an...

CORE CONCEPT AND DERIVATION

The purification of table salt relies on disrupting the solubility equilibrium by adding an external source of a shared ion.

Formula:



Solution:

- When HCl gas is passed through the solution, it heavily dissociates, providing a massive influx of Cl^{-} ions.
- Because Cl^{-} is "common" to both NaCl and HCl, Le Chatelier's principle dictates the equilibrium shifts left to consume the excess Cl^{-} .
- This forces pure NaCl to crystallize and precipitate, leaving impurities in the solution. This is a classic application of the Common Ion Effect.

Why other options are incorrect:

Hess's law relates to enthalpy changes. Henry's law relates to gas solubility. The Law of mass action defines the equilibrium expression but doesn't specifically name this precipitation phenomenon.

Question #74 Key: (A)

SET 2019

Which one of the following factors does not affect the equilibrium position?

CORE CONCEPT AND DERIVATION

The equilibrium position is determined by the ratio of products to reactants. Only factors that selectively favor forward or backward reactions can shift this position.

Formula:

$$K_c = \frac{[\text{Products}]}{[\text{Reactants}]}$$

Solution:

- A catalyst functions by lowering the activation energy for **both** the forward and reverse reactions equally.
- Because both rates increase by the same factor, the system reaches equilibrium faster, but the final ratio of products to reactants (the equilibrium position) remains completely unchanged.

Why other options are incorrect:

Concentration, temperature, and pressure all actively disturb equilibrium as dictated by Le Chatelier's Principle.

Question #75 Key: (C)

NUMS 2019

The [Formula] Unit for the reaction [Formula] is:

CORE CONCEPT AND DERIVATION

The unit of the equilibrium constant K_c is derived from the difference in the number of gaseous moles (Δn).

Formula:

$$\text{Unit} = (\text{mol dm}^{-3})^{\Delta n}$$

Solution:

- Calculate Δn for $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$.
- $\Delta n = n_{\text{products}} - n_{\text{reactants}} = 2 - 4 = -2$.
- Substitute into the formula: $(\text{mol dm}^{-3})^{-2}$.
- Distribute the exponent: $\text{mol}^{-2} \cdot (\text{dm}^{-3})^{-2} = \text{mol}^{-2} \text{dm}^{+6}$.

Why other options are incorrect:

They do not match the correct mathematical derivation of the exponent -2 applied to molarity.

Question #76 Key: (B)

NUMS 2019

Which one of the following bases has highest [Formula] value?

CORE CONCEPT AND DERIVATION

The base dissociation constant (K_b) is a measure of base strength. Strong bases completely dissociate in water and have exceptionally high K_b values.

Formula:

$$K_b = \frac{[B^+][OH^-]}{[BOH]}$$

Solution:

- NaOH is an alkali metal hydroxide, which makes it a very strong base that dissociates $\approx 100\%$ in aqueous solutions.
- Because the denominator $[BOH]$ approaches zero, its K_b value is astronomically large compared to weak bases.
- NH_4OH and CH_3NH_2 are weak bases. $\text{Ca}(\text{OH})_2$ is a strong base but has lower solubility than NaOH.

Why other options are incorrect:

Weak bases have K_b values typically in the range of 10^{-4} to 10^{-10} , which are infinitely smaller than a strong base like NaOH.

Question #77 Key: (A)

SET 2019

What is the pH of 0.1M of HCl?

CORE CONCEPT AND DERIVATION

pH is the negative base-10 logarithm of the hydrogen ion concentration. HCl is a strong acid that fully dissociates.

Formula:

$$\text{pH} = -\log[\text{H}^+]$$

Solution:

- Since HCl is a strong acid, it dissociates completely: $[\text{H}^+] = [\text{HCl}] = 0.1 \text{ M}$.
- Convert 0.1 M to scientific notation: 10^{-1} M .
- Calculate pH: $\text{pH} = -\log(10^{-1}) = -(-1) = 1$.

Why other options are incorrect:

0.1 is the concentration, not the pH. -1 would be the pH of a 10 M solution. 0.01 would be the concentration for pH 2.

Question #78 Key: (D)

NUMS 2019

The pK_a values of CH_3COOH is 4.74, the pH of equimolar solution of acetic acid and sodium acetate is:

CORE CONCEPT AND DERIVATION

The pH of a buffer solution depends on the ratio of the salt (conjugate base) to the weak acid according to the Henderson-Hasselbalch equation.

Formula:

$$\text{pH} = \text{pK}_a + \log\left(\frac{[\text{Salt}]}{[\text{Acid}]}\right)$$

Solution:

- The solution is equimolar, meaning $[\text{Salt}] = [\text{Acid}]$.
- Therefore, the ratio $\frac{[\text{Salt}]}{[\text{Acid}]} = 1$.
- The logarithm of 1 is zero: $\log(1) = 0$.
- The equation simplifies to $\text{pH} = \text{pK}_a + 0$.
- Since $\text{pK}_a = 4.74$, the pH is also exactly 4.74.

Why other options are incorrect:

Any deviation from 4.74 would require unequal concentrations of the acid and its salt.

Question #79 Key: (A)

NUMS 2019

Precipitation occurs when the product of ionic concentration is?

CORE CONCEPT AND DERIVATION

The relationship between the ionic product (Q_{sp}) and the solubility product (K_{sp}) determines whether a solution is unsaturated, saturated, or supersaturated.

Formula:



Solution:

- Q_{sp} represents the actual product of ion concentrations in a solution at any given moment.
- When $Q_{sp} > K_{sp}$, the solution contains more dissolved ions than it can stably hold at equilibrium (supersaturated).
- To restore equilibrium, the excess ions precipitate out as a solid until Q_{sp} drops down to equal K_{sp} .

Why other options are incorrect:

Less than K_{sp} means the solution is unsaturated (no precipitation). Equal to K_{sp} means it is perfectly saturated (equilibrium, no net precipitation).

Question #80 Key: (D)

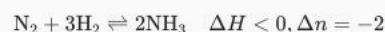
KMU 2019

Consider the reversible reaction. [Formula] The yield of [Formula] will be maximum at:

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle dictates optimal conditions for the Haber process based on thermodynamics and stoichiometry.

Formula:



Solution:

- The reaction produces heat (exothermic). Decreasing the temperature shifts the equilibrium forward to replace lost heat, yielding more NH_3 .
- The reaction goes from 4 moles of gas to 2 moles of gas. Increasing pressure favors the side with fewer moles of gas to reduce pressure. Thus, high pressure shifts it forward.
- Therefore, maximum yield requires Low Temperature and High Pressure.

Why other options are incorrect:

High temperature would shift the reaction backwards. Low pressure would favor the side with more moles (reactants).

Question #81 Key: (A)

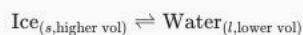
KMU 2019

Ice and water is in equilibrium with each other. By increasing the pressure the equilibrium will shift in

CORE CONCEPT AND DERIVATION

Water has the unique property where its solid phase (ice) is less dense (occupies more volume) than its liquid phase.

Formula:



Solution:

- According to Le Chatelier's Principle, increasing pressure on a system shifts the equilibrium towards the state that occupies less volume.
- Since liquid water occupies about 9% less space than solid ice, increasing pressure forces the ice to melt.
- This represents a shift to the right, which is the **forward** direction.

Why other options are incorrect:

Shifting in reverse would form more ice, which occupies more volume and would further increase the stress of pressure.

Question #82 Key: (B)

MDCAT 2019

For an equilibrium reaction; [Formula] The forward reaction is exothermic, increase in temperature shifts the ...

CORE CONCEPT AND DERIVATION

Increasing the temperature of an exothermic reaction supplies excess heat, which the system counteracts by shifting in the endothermic (reverse) direction.

Formula:



Solution:

- Because heat is a product, adding heat pushes the reaction to the left (backwards).
- As the reaction shifts left, the product SO_3 is consumed and broken down.
- Simultaneously, the reactants SO_2 and O_2 are generated.
- Thus, SO_2 and O_2 increase while SO_3 decreases.

Why other options are incorrect:

Option A violates the conservation of mass (everything cannot increase simultaneously). Option C describes a forward shift. Option D is impossible because SO_3 must be consumed to form the reactants.

Question #83 Key: (A)

MDCAT 2018

The product of the concentrations of each ion in saturated solution of a sparingly soluble salt at 298K raised...

CORE CONCEPT AND DERIVATION

This is the fundamental textbook definition of the Solubility Product Constant.

Formula:

$$K_{sp} = [M^{+y}]^x [A^{-x}]^y$$

Solution:

- For a sparingly soluble salt $M_xA_y \rightleftharpoons xM^{+y} + yA^{-x}$, the equilibrium constant is purely based on aqueous ions.
- This specific constant is termed K_{sp} (Solubility Product).

Why other options are incorrect:

K_a and K_b represent acid and base dissociation respectively. K_w is the autoionization constant of water.

Question #84 Key: (B)

MDCAT 2017

For which of the following equilibrium reaction, [Formula] has no units?

CORE CONCEPT AND DERIVATION

The unit of K_c is given by $(\text{mol dm}^{-3})^{\Delta n}$. It will be unitless only if $\Delta n = 0$.

Formula:

$$\Delta n = \Sigma \text{Moles of gaseous products} - \Sigma \text{Moles of gaseous reactants}$$

Solution:

- For option B: $\text{CO}_{(g)} + \text{H}_2\text{O}_{(g)} \rightleftharpoons \text{CO}_{2(g)} + \text{H}_{2(g)}$
- Reactant moles = $1 + 1 = 2$. Product moles = $1 + 1 = 2$.
- $\Delta n = 2 - 2 = 0$. Therefore, units cancel out.

Why other options are incorrect:

Option A has $\Delta n = 2 - 4 = -2$. Option C has $\Delta n = 2 - 3 = -1$. Option D is unbalanced as written but represents $\Delta n \neq 0$.

Question #85 Key: (C)

MDCAT 2017

Consider the following reversible reaction; [Formula]
 $\text{CH}_3\text{CH}_2\text{OH}(\text{l}) + \text{CH}_3\text{CH}_2\text{CH}_3(\text{g}) \rightleftharpoons \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3(\text{g}) + \text{CH}_3\text{CH}_2\text{OH}(\text{l})$

CORE CONCEPT AND DERIVATION

The value of K_c is a constant at a given temperature. If initial concentrations are doubled proportionally, the final equilibrium concentrations will also double to maintain the ratio of K_c .

Formula:

$$K_c = \frac{[\text{Ester}][\text{Water}]}{[\text{Acid}][\text{Alcohol}]} = 4$$

Solution:

- Initial experiment started with 1 mol of each reactant and produced 0.666 mol of products.
- By adding another 1 mol of each reactant to the equilibrium mixture, the total moles put into the system is exactly 2 moles of each reactant.
- Since the system volume is unchanged and $\Delta n = 0$, this is identical to starting a fresh reaction with double the initial concentration (2 mol each).
- Because all stoichiometry is 1:1:1:1, doubling initial reactants exactly doubles the final equilibrium concentrations to maintain $K_c = 4$.
- New Reactants = $0.333 \times 2 = 0.666$ mol.
- New Products = $0.666 \times 2 = 1.333$ mol.

Why other options are incorrect:

Other options represent asymmetrical shifts which violate the 1:1 stoichiometry of the balanced chemical equation.

Question #86 **Key: (B)**

MDCAT 2017

[Formula] is sparingly soluble having solubility product value [Formula]. What will be its solubility?

CORE CONCEPT AND DERIVATION

The solubility product (K_{sp}) relates to the molar solubility (s) based on the stoichiometry of the dissolving salt.

Formula:



$$K_{sp} = [\text{Ca}^{2+}][\text{OH}^-]^2 = (s)(2s)^2 = 4s^3$$

Solution:

- Given $K_{sp} = 6.5 \times 10^{-6}$.
- Set up the equation: $4s^3 = 6.5 \times 10^{-6}$.
- Divide by 4: $s^3 = 1.625 \times 10^{-6}$.
- Take the cube root: $s = \sqrt[3]{1.625 \times 10^{-6}} = \sqrt[3]{1.625} \times 10^{-2}$.
- Since $1^3 = 1$ and $1.2^3 = 1.728$, $\sqrt[3]{1.625}$ is approximately 1.17.
- Therefore, $s \approx 1.17 \times 10^{-2}$ M.

Why other options are incorrect:

Option A is incorrect algebra. Options C and D have positive exponents, representing impossibly high solubility for a sparingly soluble salt.

Question #87 **Key: (D)**

MDCAT 2016

Human blood maintains its pH between:

CORE CONCEPT AND DERIVATION

Human blood operates as a natural buffer system to maintain physiological homeostasis.

Formula:

$$\text{Normal Blood pH} = 7.35 \text{ to } 7.40$$

Solution:

- The optimal blood pH for enzyme function and oxygen transport is strictly regulated between 7.35 and 7.40.
- This slightly alkaline state is maintained primarily by the carbonic acid-bicarbonate buffer system.

Why other options are incorrect:

A pH below 7.35 causes acidosis, and above 7.45 causes alkalosis, both of which can be fatal. The other ranges are physically dangerous for human survival.

Question #88 **Key: (B)**

MDCAT 2016

Value of [Formula] for [Formula] system at [Formula] is equal to:

CORE CONCEPT AND DERIVATION

This is a memory-based fundamental constant for the sparingly soluble salt Lead(II) sulfate at standard room temperature.

Formula:

$$K_{sp}(\text{PbSO}_4) = 1.6 \times 10^{-8} \text{ at } 25^\circ\text{C}$$

Solution:

- The dissociation is $\text{PbSO}_{4(s)} \rightleftharpoons \text{Pb}^{2+} + \text{SO}_4^{2-}$.
- Experimental data establishes its solubility product exactly at $1.6 \times 10^{-8} \text{ mol}^2\text{dm}^{-6}$.

Why other options are incorrect:

These are incorrect magnitude variations of the standard accepted literature value.

Question #89 Key: (B)

KMU 2016

[Formula] in the equation if [Formula] then:

CORE CONCEPT AND DERIVATION

The mathematical relationship between K_p and K_c depends heavily on the sign of Δn (change in gas moles).

Formula:

$$K_p = K_c(RT)^{\Delta n}$$

Solution:

- If $\Delta n < 0$ (negative), the term $(RT)^{\Delta n}$ becomes a fraction $\frac{1}{(RT)^{|\Delta n|}}$.
- Assuming $RT > 1$ (which is true for standard thermodynamic temperatures in Kelvins), multiplying K_c by a fraction less than 1 yields a smaller number.
- Therefore, K_p will be less than K_c .

Why other options are incorrect:

$K_p = K_c$ requires $\Delta n = 0$. $K_p > K_c$ requires $\Delta n > 0$. Equilibrium constants cannot be negative (eliminating D).

Question #90 Key: (C)

KMU 2016

[Formula] values of some acids are given below; choose the weaker acid?

CORE CONCEPT AND DERIVATION

The pKa is inversely proportional to acid strength. A lower (more negative) pKa indicates a stronger acid, while a higher (less negative/positive) pKa indicates a weaker acid.

Formula:

$$\text{pKa} = -\log(K_a)$$

Solution:

- Compare the given values mathematically: $-10, -9, -7, -3$.
- The largest numerical value (closest to zero) is -3 .
- Because $-3 > -10$, H_2SO_4 has the highest pKa among the listed options.
- Therefore, it is relatively the weakest acid in this specific grouping.

Why other options are incorrect:

HClO_4 with -10 is the strongest. The others fall in between.

Question #91 Key: (C)

MDCAT 2015

During the manufacture of nitric acid, nitric oxide is oxidized to nitrogen dioxide. This reaction is given as...

CORE CONCEPT AND DERIVATION

Le Chatelier's Principle predicts how an equilibrium shifts in response to temperature changes, depending on whether the reaction is endothermic or exothermic.

Formula:

$$\Delta H < 0 \implies \text{Exothermic Reaction}$$

Solution:

- The negative sign in $\Delta H = -114 \text{ kJ/mol}$ indicates the forward reaction releases heat (exothermic).
- To maximize the yield of NO_2 , the equilibrium must be shifted forward.
- Decreasing the temperature (removing heat) shifts an exothermic reaction forward to produce more heat.
- Therefore, it must be carried out at a logically low temperature.

Why other options are incorrect:

High temperature would favor the reverse endothermic reaction, breaking down NO_2 . It is fundamentally dependent on temperature.

Question #92 Key: (C)

MDCAT 2015

What is the correct relation between pH and pKa?

CORE CONCEPT AND DERIVATION

The Henderson-Hasselbalch equation defines the relationship between the pH of a buffer, the pKa of the weak acid, and the concentrations of the acid and its conjugate base.

Formula:

$$\text{pH} = \text{pK}_a + \log \left(\frac{[\text{Base}]}{[\text{Acid}]}\right)$$

Solution:

- The standard form of the equation has a positive logarithm of Base over Acid.
- By logarithmic properties, $+\log(x/y) = -\log(y/x)$.
- Applying this: $+\log \left(\frac{[\text{Base}]}{[\text{Acid}]} \right) = -\log \left(\frac{[\text{Acid}]}{[\text{Base}]} \right)$.
- Substituting this back gives $\text{pH} = \text{pK}_a - \log \left(\frac{[\text{Acid}]}{[\text{Base}]} \right)$.

Why other options are incorrect:

Option A has a positive sign but inverted ratio. Option B applies a negative sign incorrectly to the standard ratio. Option D algebraically fails when rearranging the standard formula.

Question #93 Key: (C)

MDCAT 2015

Which one of the following is the correct representation for K_{sp} for the reaction $\text{AgCl}(s) \rightleftharpoons \text{Ag}^+(aq) + \text{Cl}^-(aq)$...

CORE CONCEPT AND DERIVATION

The solubility product constant (K_{sp}) is the equilibrium constant for a solid substance dissolving in an aqueous solution, representing the product of dissolved ion concentrations.

Formula:

$$K_{sp} = [\text{Cation}]^x [\text{Anion}]^y$$

Solution:

- For the dissolution of AgCl, the equilibrium expression is initially $K_c = \frac{[\text{Ag}^+][\text{Cl}^-]}{[\text{AgCl}]}$.
- Because AgCl is a pure solid, its concentration is constant and incorporated into the equilibrium constant.
- This creates the new constant $K_{sp} = [\text{Ag}^+][\text{Cl}^-]$.

Why other options are incorrect:

Solid reactants are never included in the denominator of a K_{sp} expression, eliminating A and B. Option D ignores the ions completely.

Question #94 Key: (C)

MDCAT 2014

The value of equilibrium constant K_p for the reaction $2\text{HF}(g) \rightleftharpoons \text{H}_2(g) + \text{F}_2(g)$ is K_c at T . Calculate Δn .

CORE CONCEPT AND DERIVATION

The relationship between K_p and K_c is governed by the change in gaseous moles (Δn) during the reaction.

Formula:

$$K_p = K_c (RT)^{\Delta n}$$

Solution:

- Calculate Δn for $2\text{HF}(g) \rightleftharpoons \text{H}_2(g) + \text{F}_2(g)$.
- Moles of gaseous products = $1 + 1 = 2$.
- Moles of gaseous reactants = 2 .
- $\Delta n = 2 - 2 = 0$.
- Therefore, $K_p = K_c (RT)^0 = K_c (1) = K_c$.
- Since $K_c = 10^{-13}$, K_p must also be 10^{-13} .

Why other options are incorrect:

Other values would only be correct if $\Delta n \neq 0$ and the term $(RT)^{\Delta n}$ altered the value of K_c .

Question #95 Key: (B)

MDCAT 2014

What will be the pH of a solution of [Formula] with a concentration of [Formula] M?

CORE CONCEPT AND DERIVATION

NaOH is a strong base that completely dissociates in water. The relationship between pH and pOH must be used.

Formula:

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pH} + \text{pOH} = 14$$

Solution:

- Since NaOH is a strong base, $[\text{OH}^-] = [\text{NaOH}] = 10^{-3} \text{ M}$.
- Calculate pOH: $\text{pOH} = -\log(10^{-3}) = 3$.
- Calculate pH: $\text{pH} = 14 - \text{pOH}$.
- $\text{pH} = 14 - 3 = 11$.

Why other options are incorrect:

Option A (3) is the pOH, not the pH, representing an acidic solution which is impossible for NaOH. Options 7 and 14 are standard pH reference points but mathematically incorrect for this concentration.

Question #96 Key: (C)

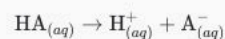
MDCAT 2013

The chemical substance, when dissolved in water, gives "[Formula]" is called:

CORE CONCEPT AND DERIVATION

The classical Arrhenius definition classifies compounds based on the ions they yield in an aqueous solution.

Formula:



Solution:

- According to Arrhenius theory, an acid is a substance that ionizes in water to yield hydrogen ions (H^+).
- For example, HCl dissolves in water to form H^+ and Cl^- .

Why other options are incorrect:

A base yields hydroxide ions (OH^-) in water. Neutral substances yield neither in excess. Amphoteric substances can act as both acids and bases depending on the environment.

Question #97 Key: (D)

MDCAT 2013

The 'pH' of our blood is:

CORE CONCEPT AND DERIVATION

Human blood operates as a natural physiological buffer system, maintaining a very narrow and specific pH range essential for life and enzyme function.

Formula:

$$\text{pH}_{\text{blood}} \approx 7.4$$

Solution:

- The carbonic acid-bicarbonate buffer system ($\text{H}_2\text{CO}_3/\text{HCO}_3^-$) is the primary buffer in human blood.
- This system tightly regulates blood pH between 7.35 and 7.40 (slightly alkaline).
- Deviations outside this range lead to conditions like acidosis or alkalosis.

Why other options are incorrect:

6.7 is severely acidic, and 7.9 is severely alkaline for human blood, both being fatal. 7.5 is outside the strict normal physiological range.

Question #98 Key: (D)

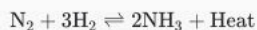
MDCAT 2012

Formation of [Formula] is reversible and exothermic process, what will happen on cooling?

CORE CONCEPT AND DERIVATION

According to Le Chatelier's Principle, changing the temperature of a system at equilibrium will shift the reaction to counteract the imposed change.

Formula:



Solution:

- The forward reaction is exothermic, meaning it produces heat.
- Cooling the system removes heat.
- To restore equilibrium, the system will shift in the direction that generates more heat.
- Therefore, it shifts forward, yielding more product (NH_3).

Why other options are incorrect:

Forming more reactants (N_2 or H_2) would require shifting backwards, which is an endothermic process and would be favored by heating, not cooling.

Question #99 Key: (C)

MDCAT 2012

A buffer solution is that which resists/minimizes the change in

CORE CONCEPT AND DERIVATION

A buffer is defined by its ability to maintain a relatively stable hydrogen ion concentration upon the addition of small amounts of acid or base.

Formula:

$$\text{pH} = \text{pK}_a + \log \frac{[\text{Salt}]}{[\text{Acid}]}$$

Solution:

- Buffers contain a weak acid and its conjugate base (or a weak base and its conjugate acid).
- These components neutralize small added amounts of H^+ or OH^- .
- As a direct result, the **pH** of the solution is kept stable.

Why other options are incorrect:

While resisting pH implicitly resists pOH, the standard chemical definition specifically highlights the resistance to changes in pH. pK_a and pK_b are constants that do not change regardless of the buffer action.

Question #100 **Key: (D)**

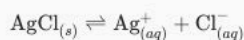
MDCAT 2011

If in [Formula] solution, some salt of [Formula] is added, [Formula] will be precipitated due to:

CORE CONCEPT AND DERIVATION

The addition of an ion that is already present in an equilibrium mixture of a sparingly soluble salt shifts the equilibrium toward solid precipitation.

Formula:



Solution:

- NaCl is a strong electrolyte and dissociates completely into Na^{+} and Cl^{-} ions.
- This significantly increases the concentration of Cl^{-} ions in the solution.
- According to Le Chatelier's Principle, the equilibrium shifts backwards to consume the excess Cl^{-} .
- This results in the precipitation of more solid AgCl, a phenomenon known as the common ion effect.

Why other options are incorrect:

Solubility generally describes the ability to dissolve, not precipitate. The term 'unsaturation' would imply more could dissolve, opposite to precipitation.

Question #101 **Key: (B)**

MDCAT 2010

Units of [Formula] for the following reaction is: [Formula] \text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}

CORE CONCEPT AND DERIVATION

The unit of the equilibrium constant K_c is entirely dependent on the change in the number of moles of gas (Δn) between products and reactants.

Formula:

$$\text{Units of } K_c = (\text{mol dm}^{-3})^{\Delta n}$$

Solution:

- First, calculate $\Delta n = n_p - n_r$.
- For $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$, moles of product $n_p = 2$.
- Moles of reactant $n_r = 1 + 1 = 2$.
- $\Delta n = 2 - 2 = 0$.
- Thus, $(\text{mol dm}^{-3})^0 = 1$, leaving the constant with no unit.

Why other options are incorrect:

Other options represent units for reactions where there is a net change in gaseous moles ($\Delta n \neq 0$).