



CHEM • CHEMISTRY

05. Liquids

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

73 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

Which type of forces exist between Iodine molecules?

- (A) Dipole-dipole forces
- (B) Dipole-induced dipole forces
- (C) Instantaneous dipole-induced dipole forces
- (D) Non-polar forces

Q2.

UHS 2024

In order to boil water at 110°C , external pressure should be

- (A) 200–760 torr
- (B) 760–1200 torr
- (C) 665–670 torr
- (D) 660–700 torr

Q3.

UHS 2024

Which one of the following do not have tendency to form hydrogen bonding?

- (A) Ammonia
- (B) Ethyl alcohol
- (C) Carboxylic acid
- (D) Hydrocarbon

Q4.

UHS 2024

Boiling point of a liquid is a temperature at which:

- (A) Surface tension is greater than the atmospheric pressure
- (B) Viscosity is less than the atmospheric pressure
- (C) Vapour pressure equals the atmospheric pressure
- (D) Viscosity equals the atmospheric pressure

Q5.

SZABMU 2024

Water is liquid at room temperature as compared to ammonia and hydrogen disulphide due to presence of

-
- (A) Co-ordinate covalent bond
 - (B) Hydrogen bond
 - (C) Ionic bond
 - (D) Metallic bond

Q6.

SZABMU 2024

For boiling point, vapor pressure of liquid does not depend upon -----.

- (A) Amount of liquid
- (B) External atmospheric pressure
- (C) Intermolecular forces
- (D) Type of bond

Q7.

SZABMU 2024

Which one of the following noble gases will have highest boiling point?

- (A) Kr
- (B) Ar
- (C) Ne
- (D) He

Q8.

SZABMU 2024

The compound which exhibits highest vapour pressure is:

- (A) Water
- (B) HF
- (C) Petrol
- (D) Acetic acid

Q9.

KMU 2024

Molar heat of vaporization of water is:

- (A) 40.7 cal/mol
- (B) 40.7 J/mol
- (C) 40.7 kcal/mol
- (D) 40.7 kJ/mol

Q10.

KMU 2024

Distillation under very reduced pressure is distillation:

- (A) Destructive
- (B) Fractional
- (C) Steam
- (D) Vacuum

Q11.

DUHS 2024

Which of the following possesses the weakest London dispersion forces?

- (A) F₂
- (B) Br₂
- (C) Cl₂
- (D) I₂

Q12.

DUHS 2024

Which of the following liquids show maximum surface tension?

- (A) Water
- (B) Mercury
- (C) Ethyl alcohol
- (D) Chloroform

Q13.

BUMHS 2024

Which of the following is not a result of capillary action?

- (A) Rise of water from soil to plant
- (B) Absorption of water on cotton
- (C) Movement of blood in veins
- (D) spreading of ink on blotting paper

Q14.

NUMS 2024

The maximum polarizability is exhibited in:

- (A) C₆H₁₄
- (B) C₃H₆
- (C) C₅H₁₂
- (D) C₂H₆

Q15.

NUMS 2024

If the external pressure is reduced to half, the boiling point of Ethanol will be:

- (A) Greater than 78°C
- (B) Less than 78°C
- (C) Equal to 78°C
- (D) Reduced to half

Q16.

UHS 2023

Which of the following factor does not affect the magnitude of V.P?

- (A) Amount of liquid
- (B) Size of molecule
- (C) Temperature of liquid
- (D) Intermolecular forces

Q17.

UHS 2023

Which is not a property of liquid?

- (A) Osmotic pressure
- (B) Freezing point
- (C) Diffusion
- (D) Melting

Q18.

SZABMU 2023

Which of the following has the lowest vapour pressure at 20°C?

- (A) Diethyl ether
- (B) Chloroform
- (C) Carbon tetrachloride
- (D) Water

Q19.

SZABMU 2023

The force of attraction among H₂ molecules in solid H₂ are:

- (A) Hydrogen bonds
- (B) Covalent bonds
- (C) Co-ordinate covalent bonds
- (D) Van der Waal's Forces

Q20.

SZABMU 2023

Which of the following molecules are soft and have weak intermolecular forces?

- (A) H_2O
- (B) I_2
- (C) Sugar
- (D) Graphite

Q21.

KMU 2023

Compounds having lowest boiling point is:

- (A) Carbon tetrachloride
- (B) Ethyl alcohol
- (C) Benzene
- (D) Acetic acid

Q22.

KMU 2023

Which of the following can form hydrogen bonding with each other?

- (A) Methanal & Ethanal
- (B) Propanone & ethyl methyl ketone
- (C) 3° Amine & H_2O
- (D) Acetone & Acetaldehyde

Q23.

DUHS 2023

Water rises in capillary tube because of:

- (A) Cohesive force & adhesive forces are same
- (B) Adhesive forces of molecules exceed cohesive force
- (C) Cohesive force is greater than adhesive force
- (D) Cohesive force and adhesive force to explain the property in the above question is irrelevant

Q24.

DUHS 2023

Which of the following influences the variation of temperature at which boiling of liquid takes place?

- (A) Outside pressure
- (B) Outside temperature
- (C) Volume of container
- (D) Amount of liquid

Q25.

BUMHS 2023

At room temperature, Glycerin boils at 290°C . What is the boiling point of Glycerin under vacuum distillation at 50 torr?

- (A) 320°C
- (B) 310°C
- (C) 300°C
- (D) 210°C

Q26.

BUMHS 2023

The polar part of the soap and detergents dissolve in water molecules due to:

- (A) Dipole – dipole forces
- (B) Dipole – induced dipole forces
- (C) Hydrogen bonding
- (D) London dispersion forces

Q27.

BUMHS 2023

What is the fact due to which the branching decreases boiling point?

- (A) As branching increases the attractive forces between molecules
- (B) As branching increases it decreases attractive forces
- (C) As branching increases it increases surface area for making attractive forces
- (D) As branching increases it decreases the surface area for attractive forces

Q28.

NUMS 2023

Vapour pressure is independent of which factor?

- (A) Temperature
- (B) Intermolecular forces
- (C) Density of liquid
- (D) Surface area of liquid

Q29.

NUMS 2023

The boiling point of ether is less as compared to alcohols and phenols due to:

- (A) Functional group
- (B) Intermolecular forces
- (C) Nature of alkyl groups
- (D) Isomerism

Q30.

NUMS 2023

When 2 ice cubes are pressed over each other they unite to form one cube due to:

- (A) Dipole-dipole attraction
- (B) Covalent attraction
- (C) Van Der Waal's forces
- (D) H – bonding

Q31.

UHS 2022

In liquid, with the change in dipole–dipole forces, there is a change in some physical properties. Select the property which is not affected by the strength of dipole–dipole forces?

- (A) B.Pt.
- (B) Heat of sublimation
- (C) Heat of vaporization
- (D) Moles

Q32.

UHS 2022

Which of the following factor does not affect the magnitude of V.P?

- (A) Amount of liquid
- (B) Size of molecule
- (C) Temperature of liquid
- (D) Intermolecular forces

Q33.

SZABMU 2022

When 2 ice cubes are pressed over each other they unite to form one cube due to:

- (A) Dipole–dipole attraction
- (B) Covalent attraction
- (C) Van Der Waal's forces
- (D) H–bonding

Q34.

SZABMU 2022

The strongest hydrogen bond is present in:

- (A) H_2S
- (B) HF
- (C) H_2O
- (D) NH_3

Q35.

SZABMU 2022

Which of the following has highest surface tension?

- (A) Benzene
- (B) Alcohols
- (C) Ether
- (D) Water

Q36.

SZABMU 2022

Ice floats on the surface of water due to:

- (A) Large bond length
- (B) Cubic structure of ice
- (C) Weak intermolecular forces
- (D) Empty spaces in the structure of ice

Q37.

SZABMU 2022

Which of the following has highest boiling point?

- (A) C_4H_{10}
- (B) C_6H_{14}
- (C) $\text{C}_{10}\text{H}_{22}$
- (D) C_3H_8

Q38.

KMU 2022

Exceptionally low acidic strength of HF is due to:

- (A) Strong polar bond between H & F
- (B) Smaller size of fluorine
- (C) More electronegativity of fluorine
- (D) Strong hydrogen bonding

Q39.

KMU 2022

Which of the following compounds has lowest boiling point?

- (A) Water
- (B) Ethanol
- (C) Hydrogen sulphide
- (D) Acetic acid

Q40.

KMU 2022

A pressure cooker reduces cooking time because:

- (A) A large heat is used
- (B) Heat is more evenly distributed
- (C) The higher pressure softens food inside
- (D) The boiling point of water rises inside

Q41.

KMU 2022

In which of the following molecule hydrogen bond is not present?

- (A) H_2O
- (B) HF
- (C) CH_4
- (D) NH_3

Q42.

KMU 2022

The distillation carried out under reduced pressure is called:

- (A) Steam distillation
- (B) Simple distillation
- (C) Fractional distillation
- (D) Vacuum distillation

Q43.

DUHS 2022

Viscosity is the measure of:

- (A) Volume
- (B) Resistance in the flow of a liquid
- (C) Fluidity of liquid
- (D) Mass

Q44.

DUHS 2022

The two crystals NaNO_3 & CaCO_3 are both trigonal they are:

- (A) Isomers
- (B) Polymorphs
- (C) Allotropes
- (D) Isomorphs

Q45.

DUHS 2022

Falling drop of liquid is spherical due to its:

- (A) Evaporation on exposure
- (B) Surface tension
- (C) Atomic structure
- (D) Viscosity

Q46.

BUMHS 2022

Viscosity of liquid decreases with an increase in:

- (A) Molecular mass
- (B) Temperature
- (C) Atmosphere pressure
- (D) Intermolecular forces

Q47.

NUMS 2022

The boiling point of compound is mostly raised by:

- (A) Dipole-induced dipole interaction
- (B) London dispersion forces
- (C) Intra molecular H - bonding
- (D) Inter molecular H - bonding

Q48.

NUMS 2022

Which of the following statement explains solubility of ionic substance in water?

- (A) Water molar mass is 18.02
- (B) Water molecule is polar
- (C) Water forms dative bonding
- (D) Water has high density

Q49.

PMDC 2021

In which of the following water evaporate earlier:

- (A) Cup
- (B) Saucepan
- (C) Glass
- (D) Small bowl

Q50.

PMDC 2021

Which instrument is used to measure the vapor pressure of a liquid?

- (A) Barometer
- (B) Manometer
- (C) Thermometer
- (D) Sphygmomanometer

Q51.

PMDC 2021

Which of the following has highest vapour pressure?

- (A) Diethyl ether
- (B) Ethanol
- (C) Water
- (D) Ethylene glycol

Q52.

PMDC 2021

At 0°C , what is the physical state of water?

- (A) Ice
- (B) Liquid
- (C) Vapour
- (D) Both ice and liquid

Q53.

PMDC 2020

 CO_2 and SO_2 both are tri-atomic molecules but heat of vaporization of SO_2 is greater than that of CO_2 due to:

- (A) High electronegativity of S
- (B) Greater size of SO_2
- (C) SO_2 is polar and CO_2 is non-polar
- (D) SO_2 is more acidic than CO_2

Q54.

PMDC 2020

Which of the following has the lowest vapor pressure at 20°C ?

- (A) Diethyl ether
- (B) Chloroform
- (C) Carbon tetrachloride
- (D) Water

Q55.

PMDC 2020

Which of the following is not a molecular solid?

- (A) Bromine
- (B) Sulphur
- (C) Phosphorus
- (D) Carbon dioxide

Q56.

NUMS 2019

At 1489 mmHg, water will boil at:

- (A) 120°C
- (B) 110°C
- (C) 100°C
- (D) 90°C

Q57.

NUMS 2019

Water has maximum density at:

- (A) -4°C
- (B) 1°C
- (C) 0°C
- (D) 4°C

Q58.

MDCAT 2019

Which of the following substances exhibits hydrogen bonding?

- (A) H₂S
- (B) HI
- (C) NH₃
- (D) SiH₄

Q59.

MDCAT 2019

An inter molecular force of attraction X is relatively stronger than the other inter molecular forces, it stabilizes α -helix and β -pleated sheets of proteins. The double helical structure of DNA is also stabilized by this force of attraction. Identify X.

- (A) Dipole-dipole attraction
- (B) Hydrogen bonding
- (C) Ionic interactions
- (D) Van der Waal's Forces

Q60.

KMU 2019

At higher altitude, the boiling point of water is less than 100°C, this is because of:

- (A) Higher atmospheric pressure
- (B) Weak hydrogen bonding
- (C) No change in atmospheric pressure
- (D) Lower atmospheric pressure

Q61.

KMU 2019

Steam causes severe burns than boiling water. It is due to:

- (A) Absence of hydrogen bonding
- (B) High latent heat of vaporization
- (C) Freely moving molecules
- (D) Statement is incorrect

Q62.

MDCAT 2019

According to Watson and Crick's model of DNA, the DNA molecule consists of a double helix. What type of forces are responsible to keep two strands of DNA together?

- (A) Hydrogen bonding
- (B) Van der Waal's forces
- (C) Ionic bonding
- (D) Dipole-induces dipole forces

Q63.

MDCAT 2017

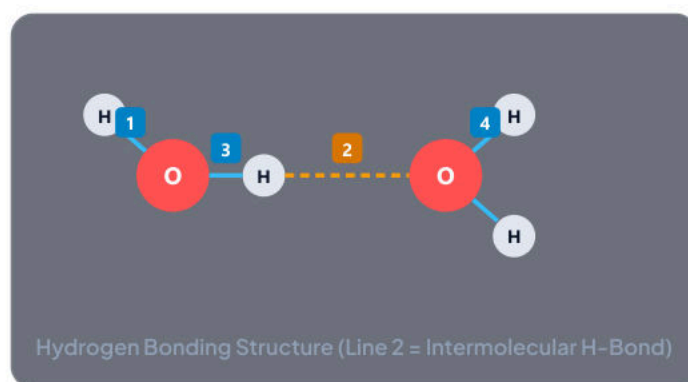
What is reason that the ice at 0°C occupies more volume than water?

- (A) Empty spaces
- (B) Intermolecular forces
- (C) Ionic bond
- (D) Debye forces

Q64.

MDCAT 2017

Which line in the following structure represents hydrogen bonding?



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

Q65.

MDCAT 2015

Which one of the following hydrogen bond is stronger than others?

- (A) $\text{N}^{\delta-} - \text{H}^{\delta+} \cdots \text{N}^{\delta-} - \text{H}^{\delta+}$
 (B) $\text{O}^{\delta-} - \text{H}^{\delta+} \cdots \text{O}^{\delta-} - \text{H}^{\delta+}$
 (C) $\text{F}^{\delta-} - \text{H}^{\delta+} \cdots \text{F}^{\delta-} - \text{H}^{\delta+}$
 (D) $\text{N}^{\delta-} - \text{H}^{\delta+} \cdots \text{O}^{\delta-} - \text{H}^{\delta+}$

Q66.

MDCAT 2014

Ice is less dense than water at:

- (A) 0°C
 (B) 4°C
 (C) -4°C
 (D) 2°C

Q67.

MDCAT 2014

In crystal lattice of ice, each O-atom of water molecule is attached to:

- (A) Four H-atoms
 (B) Two H-atoms
 (C) One H-atom
 (D) Three H-atoms

Q68.

MDCAT 2012

Correct order of boiling points of the given liquids is:

- (A) $\text{H}_2\text{O} > \text{HF} > \text{HCl} > \text{NH}_3$
 (B) $\text{H}_2\text{O} > \text{HF} > \text{NH}_3 > \text{HCl}$
 (C) $\text{HF} > \text{H}_2\text{O} > \text{HCl} > \text{NH}_3$
 (D) $\text{HF} > \text{H}_2\text{O} > \text{NH}_3 > \text{HCl}$

Q69.

MDCAT 2012

In 'H-F' bond, electronegativity difference is 2.0. What is the type of this bond?

- (A) Polar covalent bond
 (B) π (π) bond
 (C) Non-polar covalent bond
 (D) Co-ordinate covalent bond

Q70.

MDCAT 2011

DNA molecule is double stranded, in which two chains of DNA are twisted around each other by:

- (A) Hydrogen bonds
 (B) Van der Waal's forces
 (C) Covalent bonds
 (D) Dative bonds

Q71.

MDCAT 2011

Boiling point of water is higher than petrol, because intermolecular forces in water are:

- (A) Weaker than petrol
 (B) Stronger than petrol
 (C) Same as in petrol
 (D) Negligible

Q72.

MDCAT 2010

Metallic conduction involves the relatively free movement of their----- throughout the metallic lattice:

- (A) Atoms
 (B) Electrons
 (C) Ions
 (D) Molecules

Q73.

MDCAT 2010

Which type of force is present in gasoline?

- (A) Dipole-dipole forces
 (B) Hydrogen bonding
 (C) Dipole-induced dipole forces
 (D) London dispersion forces

RAPID 5–COLUMN ANSWER KEY

Official PMDC verified answer keys for 05. Liquids.

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Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD	Q#	KEY	BOARD
1	C	UHS 2024	16	A	UHS 2023	31	D	UHS 2022	46	B	BUMHS 2022	61	B	KMU 2019
2	B	UHS 2024	17	D	UHS 2023	32	A	UHS 2022	47	D	NUMS 2022	62	A	MDCAT 2019
3	D	UHS 2024	18	D	SZABMU 2023	33	D	SZABMU 2022	48	B	NUMS 2022	63	A	MDCAT 2017
4	C	UHS 2024	19	D	SZABMU 2023	34	B	SZABMU 2022	49	B	PMDC 2021	64	B	MDCAT 2017
5	B	SZABMU 2024	20	B	SZABMU 2023	35	D	SZABMU 2022	50	B	PMDC 2021	65	C	MDCAT 2015
6	A	SZABMU 2024	21	A	KMU 2023	36	D	SZABMU 2022	51	A	PMDC 2021	66	A	MDCAT 2014
7	A	SZABMU 2024	22	C	KMU 2023	37	C	SZABMU 2022	52	D	PMDC 2021	67	A	MDCAT 2014
8	C	SZABMU 2024	23	B	DUHS 2023	38	D	KMU 2022	53	C	PMDC 2020	68	B	MDCAT 2012
9	D	KMU 2024	24	A	DUHS 2023	39	C	KMU 2022	54	D	PMDC 2020	69	A	MDCAT 2012
10	D	KMU 2024	25	D	BUMHS 2023	40	D	KMU 2022	55	A	PMDC 2020	70	A	MDCAT 2011
11	A	DUHS 2024	26	C	BUMHS 2023	41	C	KMU 2022	56	A	NUMS 2019	71	B	MDCAT 2011
12	B	DUHS 2024	27	D	BUMHS 2023	42	D	KMU 2022	57	D	NUMS 2019	72	B	MDCAT 2010
13	C	BUMHS 2024	28	D	NUMS 2023	43	B	DUHS 2022	58	C	MDCAT 2019	73	D	MDCAT 2010
14	A	NUMS 2024	29	B	NUMS 2023	44	D	DUHS 2022	59	B	MDCAT 2019			
15	B	NUMS 2024	30	D	NUMS 2023	45	B	DUHS 2022	60	D	KMU 2019			

TOTAL
MCQS

73

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: (C)

UHS 2024

Which type of forces exist between Iodine molecules?

CORE CONCEPT AND DERIVATION

Intermolecular forces in perfectly non-polar molecules rely solely on the random, temporary movement of electron clouds.

Formula:

Not applicable.

Solution:

- Iodine (I_2) is a homonuclear diatomic molecule. Because both iodine atoms share the electrons equally, the molecule is perfectly symmetrical and non-polar, possessing a net dipole moment of zero.
- At any given instant, the large electron cloud can randomly shift to one side, creating a temporary, instantaneous dipole.
- This temporary dipole distorts the electron cloud of a neighboring I_2 molecule, creating an "induced" dipole.
- The resulting electrostatic attraction is called an Instantaneous dipole-induced dipole force (formally known as London Dispersion Forces).

Why other options are incorrect:

Dipole-dipole forces require permanent polarity, which iodine lacks. Dipole-induced dipole forces require a mixture of polar and non-polar substances.

Question #2 Key: (B)

UHS 2024

In order to boil water at [Formula], external pressure should be

CORE CONCEPT AND DERIVATION

A liquid boils when its vapor pressure equals the external ambient pressure. Modifying the external pressure shifts the boiling temperature.

Formula:

$$P_{\text{ext}} \uparrow \implies \text{Boiling Point} \uparrow$$

Solution:

- Under standard atmospheric pressure (exactly 760 torr), pure water boils at exactly 100°C .
- If we wish to force water to remain a liquid until it reaches a higher temperature of 110°C , we must suppress the vapor bubbles from forming.
- To do this, we must apply an external pressure that is significantly **greater** than standard atmospheric pressure (> 760 torr).
- The only option range that provides pressures greater than 760 torr is 760–1200 torr.

Why other options are incorrect:

Options A, C, and D represent pressures strictly lower than standard atmospheric pressure (< 760 torr). Subjecting water to these lower pressures would cause it to boil at temperatures *below* 100°C , not above it.

Question #3 Key: (D)

UHS 2024

Which one of the following do not have tendency to form hydrogen bonding?

CORE CONCEPT AND DERIVATION

Hydrogen bonding has strict atomic requirements: a hydrogen atom must be covalently attached to a very small, highly electronegative atom (specifically N, O, or F).

Formula:

Not applicable.

Solution:

- Ammonia (NH_3) has N-H bonds.
- Ethyl alcohol ($\text{C}_2\text{H}_5\text{OH}$) has an O-H bond.
- Carboxylic acids (R-COOH) have an O-H bond. All three of these can readily donate and accept strong hydrogen bonds.
- Hydrocarbons (like methane or hexane) consist purely of Carbon and Hydrogen. Because the electronegativity difference between C (2.5) and H (2.1) is extremely small, the bonds are practically non-polar.
- Without highly polarized hydrogens or lone pairs on electronegative atoms, hydrocarbons have zero tendency or capacity to form hydrogen bonds.

Why other options are incorrect:

The other options contain functional groups that are textbook examples of hydrogen bond participants.

Question #4 Key: (C)

UHS 2024

Boiling point of a liquid is a temperature at which:

CORE CONCEPT AND DERIVATION

The boiling point is rigorously defined by thermodynamics as a state of mechanical equilibrium between the internal push of the liquid's vapor and the external push of the atmosphere.

Formula:

$$P_{\text{vapor}} = P_{\text{atm}}$$

Solution:

- When a liquid is heated, its molecules gain kinetic energy, and its vapor pressure steadily rises.
- Evaporation occurs only at the surface. However, for a liquid to *boil*, massive vapor bubbles must form within the bulk interior of the liquid and rise to the top.
- These bubbles can only form and survive without collapsing when the internal outward pressure pushing them open (the vapor pressure) matches or exceeds the downward crushing force of the atmosphere (the atmospheric pressure).
- Thus, boiling strictly occurs at the exact temperature where Vapour pressure = Atmospheric pressure.

Why other options are incorrect:

Surface tension and viscosity are fluid dynamic properties, not pressures. Equating them to atmospheric pressure is dimensionally and physically nonsensical.

Question #5 Key: (B)

SZABMU 2024

Water is liquid at room temperature as compared to ammonia and hydrogen disulphide due to presence of ____.

CORE CONCEPT AND DERIVATION

The physical state of a molecular substance at room temperature depends entirely on how tightly its molecules are bound together by intermolecular forces.

Formula:

Not applicable.

Solution:

- Hydrogen disulphide (H_2S) relies on weak dipole-dipole forces and is a gas.
- Ammonia (NH_3) has hydrogen bonding, but each molecule only has one lone pair, limiting the network size, making it a gas at room temperature.
- Water (H_2O) is unique. Its oxygen atom has two highly polar hydrogens and two lone pairs. This allows every single water molecule to form up to four strong **Hydrogen bonds**, creating a massive, tight 3D cohesive network.
- This incredibly strong network requires substantial energy to break apart, maintaining water strictly in the liquid state at standard room temperature.

Why other options are incorrect:

Water is a covalent compound. It lacks the metallic lattice required for metallic bonds, the electron transfer required for ionic bonds, and its state is not dictated by coordinate bonds.

Question #6 Key: (A)

SZABMU 2024

For boiling point, vapor pressure of liquid does not depend upon ____.

CORE CONCEPT AND DERIVATION

Vapor pressure is an intensive thermodynamic property. Intensive properties depend strictly on the intrinsic nature of the substance and temperature, not on its macroscopic scale.

Formula:

Not applicable.

Solution:

- The vapor pressure of a substance is determined by how forcefully its molecules try to escape into the gas phase. This is controlled by the strength of its **Intermolecular forces** (which are dictated by the **Type of bond**).
- However, vapor pressure is an equilibrium ratio. Whether you have 10 mL of water in a beaker or 10,000 Liters of water in a tank, the equilibrium pressure the vapor exerts at a given temperature is mathematically identical.
- Therefore, the physical **Amount of liquid** has absolutely zero effect on the magnitude of the vapor pressure.

Why other options are incorrect:

Intermolecular forces and bond types chemically define the vapor pressure. (Note: External pressure defines the *boiling point* threshold, though strictly speaking, the intrinsic vapor pressure curve itself is independent of external pressure. However, in this multiple-choice context, macroscopic "amount" is the universal textbook distractor).

Question #7 Key: (A)

SZABMU 2024

Which one of the following noble gases will have highest boiling point?

CORE CONCEPT AND DERIVATION

Noble gases are non-polar, monoatomic elements. The only intermolecular forces acting between them are London dispersion forces, which scale with the polarizability of the atom.

Formula:

$$\text{Polarizability} \propto \text{Atomic Size/Number of Electrons}$$

Solution:

- As we move down Group 18 in the periodic table (He, Ne, Ar, Kr, Xe, Rn), atomic radius and total electron count increase.
- A larger electron cloud is more diffuse and held less tightly by the nucleus, making it much easier to distort. This high polarizability creates stronger, more prominent temporary dipoles.
- Stronger London dispersion forces require more thermal energy to overcome.
- Among the given options, Krypton (Kr) is the largest atom located furthest down the group. Therefore, it possesses the strongest dispersion forces and the highest boiling point.

Why other options are incorrect:

Helium is the smallest element with the tightest electron cloud, making it the least polarizable with the lowest boiling point of any known substance. Ne and Ar are intermediate.

Question #8 Key: (C)

SZABMU 2024

The compound which exhibits highest vapour pressure is:

CORE CONCEPT AND DERIVATION

Vapor pressure is inversely related to the strength of intermolecular forces. Weaker forces mean less energy is required for molecules to escape into the vapor phase, resulting in high volatility (high vapor pressure).

Formula:

$$\text{V.P.} \propto \frac{1}{\text{IMF Strength}}$$

Solution:

- Water (H₂O), Hydrogen fluoride (HF), and Acetic acid (CH₃COOH) all contain highly electronegative atoms covalently bonded to hydrogen. Consequently, they all exhibit massive, highly stabilizing hydrogen bonding networks.
- Petrol (a mixture of hydrocarbons like octane) is entirely non-polar. It cannot form hydrogen bonds or dipole-dipole attractions.
- Because Petrol is held together solely by weak London dispersion forces, its molecules easily and rapidly escape into the air. Thus, it exerts a massively higher vapor pressure compared to the others.

Why other options are incorrect:

The robust hydrogen bonding in water, HF, and acetic acid anchors their molecules in the liquid state, severely dampening their vapor pressures.

Question #9 Key: (D)

KMU 2024

Molar heat of vaporization of water is:

CORE CONCEPT AND DERIVATION

The molar heat of vaporization (ΔH_{vap}) is a standard thermodynamic constant representing the energy required to vaporize one mole of a liquid at its boiling point under standard pressure.

Formula:

$$\Delta H_{\text{vap}} = H_{\text{vapor}} - H_{\text{liquid}}$$

Solution:

- Water has an exceptionally high heat of vaporization due to its extensive hydrogen-bonded network, requiring massive energy to completely separate the molecules into a gas.
- The experimentally determined value for the molar heat of vaporization of water is strictly 40.7 kilojoules per mole (kJ/mol).
- This high value is the reason sweating is such a highly efficient cooling mechanism for the human body.

Why other options are incorrect:

Options A and B use units that are thousands of times too small (cal and Joules). Option C uses kilocalories, but 40.7 kcal/mol equals approximately 170 kJ/mol, which is incorrect. The numeric value 40.7 corresponds specifically to kilojoules.

Question #10 Key: (D)

KMU 2024

Distillation under very reduced pressure is distillation:

CORE CONCEPT AND DERIVATION

When organic compounds have very high boiling points, they often chemically decompose before they can reach the temperature required to boil at normal atmospheric pressure.

Formula:

$$P_{\text{external}} \downarrow \Rightarrow \text{Boiling Point} \downarrow$$

Solution:

- To safely distill these sensitive compounds, a vacuum pump is attached to the distillation apparatus to forcefully remove air and drastically lower the internal pressure.
- Because boiling occurs when vapor pressure equals external pressure, lowering the external pressure means the liquid will boil at a much cooler, safer temperature.
- This specific technique is formally classified as **Vacuum distillation**.

Why other options are incorrect:

Fractional distillation separates mixtures based on close boiling points at normal pressure. Steam distillation uses steam to lower the partial pressure of immiscible oils. Destructive distillation is a high-heat decomposition process in the absence of air.

Question #11 Key: (A)

DUHS 2024

Which of the following possesses the weakest London dispersion forces?

CORE CONCEPT AND DERIVATION

London dispersion forces are the only intermolecular forces present in non-polar diatomic halogens. The strength of these forces depends directly on atomic size and polarizability.

Formula:

$$\text{LDF Strength} \propto \text{Polarizability} \propto \text{Electron Cloud Size}$$

Solution:

- As you move down Group 17 (Fluorine, Chlorine, Bromine, Iodine), the atoms acquire more electron shells, dramatically increasing in size.
- A larger electron cloud is held less tightly by the nucleus, making it easier to distort into temporary dipoles (high polarizability).
- Fluorine (F_2) is at the very top of the group. It is the smallest molecule with the fewest electrons.
- Because its electrons are held tightly to the nucleus, it has very low polarizability, resulting in the **weakest** London dispersion forces. (This is why it is a highly volatile gas at room temperature, while Iodine is a solid).

Why other options are incorrect:

Chlorine is larger, Bromine is a liquid, and Iodine is a solid, proving that their dispersion forces are increasingly stronger.

Question #12 Key: (B)

DUHS 2024

Which of the following liquids show maximum surface tension?

CORE CONCEPT AND DERIVATION

Surface tension arises from the net inward cohesive forces pulling on molecules at the surface of a liquid. Stronger cohesive forces result in higher surface tension.

Formula:

$$\gamma \propto \text{Cohesive Force Strength}$$

Solution:

- Water and Ethyl alcohol rely on hydrogen bonding. Water has a high surface tension for a molecular liquid (approx 72 mN/m) due to its dense H-bond network.
- Chloroform relies on weaker dipole-dipole forces.
- Mercury (Hg), however, is a liquid metal. It is not held together by standard intermolecular forces, but by **Metallic Bonding**.
- The electrostatic sea of delocalized electrons creates an incredibly powerful cohesive force between the mercury atoms, resulting in a massive surface tension (approx 485 mN/m), pulling it tightly into spherical beads.

Why other options are incorrect:

No molecular hydrogen bond (as in water or alcohol) can compete in strength with the pure metallic bonding found in liquid mercury.

Question #13 Key: (C)

BUMHS 2024

Which of the following is not a result of capillary action?

CORE CONCEPT AND DERIVATION

Capillary action is the spontaneous flow of liquid into a narrow tube or porous material due to strong adhesive forces overcoming cohesive forces and gravity.

Formula:

Not applicable.

Solution:

- Plants utilize capillary action in their xylem to help pull water up from the soil.
- Cotton towels and blotting paper consist of millions of microscopic cellulose fibers that create tiny, narrow channels perfectly suited to aggressively wick liquids via capillary action.
- However, the macroscopic movement of blood through human **veins** is driven mechanically. It relies on the immense pumping pressure generated by the heart, the squeezing action of skeletal muscles, and one-way physical valves preventing backflow. It is a hydraulic system, not a passive capillary pull.

Why other options are incorrect:

Options A, B, and D are all classic textbook examples of passive capillary mechanics acting through tiny, porous networks.

Question #14 Key: (A)

NUMS 2024

The maximum polarizability is exhibited in:

CORE CONCEPT AND DERIVATION

Polarizability is a measure of how easily the electron cloud of an atom or molecule can be distorted to induce a temporary dipole. It strictly depends on the size and volume of the electron cloud.

Formula:

$$\alpha \propto \text{Molecular Size} / \text{Number of Electrons}$$

Solution:

- All the options are aliphatic hydrocarbons governed entirely by London dispersion forces.
- To determine polarizability, we simply evaluate the size of the molecules. A longer carbon chain has more electrons spread over a much larger volume.
- Option D is Ethane (2 carbons), B is Propene (3 carbons), C is Pentane (5 carbons), and A is Hexane (6 carbons).
- Hexane (C_6H_{14}) is the largest molecule in the list. Its massive, extended electron cloud is the least tightly controlled by the nuclei, making it the easiest to dynamically distort. Thus, it exhibits the maximum polarizability.

Why other options are incorrect:

The other molecules have shorter carbon chains, fewer electrons, and smaller, tighter electron clouds, resulting in lower polarizability and lower boiling points.

Question #15 Key: (B)

NUMS 2024

If the external pressure is reduced to half, the boiling point of Ethanol will be:

CORE CONCEPT AND DERIVATION

The boiling point is the specific temperature at which a liquid's internal vapor pressure becomes exactly equal to the external atmospheric pressure pushing down on it.

Formula:

$$P_{\text{external}} \downarrow \implies \text{Boiling Temperature} \downarrow$$

Solution:

- Under standard 1 atm (760 torr) pressure, the normal boiling point of ethanol is 78°C.
- If we reduce the external pressure to half (e.g., placing it in a partial vacuum or on a very high mountain), the atmosphere provides much less downward resistance against vapor formation.
- Consequently, the ethanol does not need to be heated as much to match this lower pressure. It will achieve equilibrium at a lower temperature.
- Therefore, the boiling point will be less than 78°C.

Why other options are incorrect:

The boiling point doesn't stay the same (C) or increase (A) because thermodynamic equilibrium rules dictate otherwise. It does not reduce exactly to half (D) because the relationship between vapor pressure and temperature is logarithmic (Clausius-Clapeyron equation), not strictly linear.

Question #16 Key: (A)

UHS 2023

Which of the following factor does not affect the magnitude of V.P?

CORE CONCEPT AND DERIVATION

Vapor pressure is determined by the inherent chemical nature of a substance and its thermal state. It is strictly an intensive property, independent of mass or volume.

Formula:

Not applicable.

Solution:

- At any given temperature, the vapor pressure of a liquid is a fixed constant representing the equilibrium between molecules escaping into a gas and returning to the liquid.
- A single drop of water and an entire swimming pool of water (at the exact same temperature) exert the exact same vapor pressure. Therefore, the physical Amount of Liquid has zero effect on the magnitude of the vapor pressure.

Why other options are incorrect:

Temperature dramatically changes vapor pressure. Intermolecular forces and molecular size physically hinder molecules from escaping, directly dictating the equilibrium vapor pressure.

Question #17 Key: (D)

UHS 2023

Which is not a property of liquid?

CORE CONCEPT AND DERIVATION

States of matter undergo distinct, direction-specific phase transitions.

Formula:

Not applicable.

Solution:

- Liquids can be cooled down to their "Freezing point" to become solids.
- Liquids readily "Diffuse" into one another.
- Liquids serve as solvents generating "Osmotic pressure" across semipermeable membranes.
- However, "Melting" is explicitly defined as the phase transition from a Solid to a Liquid. A substance that is already in the liquid state cannot melt. Therefore, melting is a property of solids, not liquids.

Why other options are incorrect:

The other options are standard physical or colligative properties inherently applicable to substances in the liquid state.

Question #18 Key: (D)

SZABMU 2023

Which of the following has the lowest vapour pressure at [Formula] ?

CORE CONCEPT AND DERIVATION

Vapor pressure is inversely proportional to the strength of intermolecular forces. Liquids with stronger intermolecular forces evaporate less readily, leading to lower vapor pressure.

Formula:

$$\text{Vapor Pressure} \propto \frac{1}{\text{IMF Strength}}$$

Solution:

- Diethyl ether, chloroform, and carbon tetrachloride are highly volatile organics governed by relatively weak dipole-dipole or London dispersion forces.
- Water (H₂O) molecules form a strong, extensive network of hydrogen bonds.
- Because water's intermolecular forces are exceptionally strong, very few molecules escape into the vapor phase at 20°C, giving it the lowest vapor pressure of the group (approx 17.5 torr).

Why other options are incorrect:

Diethyl ether has the weakest forces and hence the *highest* vapor pressure. Chloroform and CCl₄ are also much more volatile than water.

Question #19 Key: (D)

SZABMU 2023

The force of attraction among [Formula] molecules in solid [Formula] are:

CORE CONCEPT AND DERIVATION

Diatomic hydrogen (H_2) is a perfectly non-polar molecule with a completely symmetrical electron cloud.

Formula:

Not applicable.

Solution:

- Within an H_2 molecule, the two hydrogen atoms are held by a non-polar covalent bond.
- However, the question asks for the force among separate H_2 molecules in a solid crystal lattice.
- Because H_2 is strictly non-polar and lacks any highly electronegative atom (N, O, F), it cannot form dipole-dipole interactions or hydrogen bonds.
- The only possible forces between these non-polar molecules are instantaneous induced-dipole attractions, collectively known as London dispersion forces, which fall under the umbrella category of Van der Waals forces.

Why other options are incorrect:

Covalent bonds exist *inside* the molecule, not *between* them. Hydrogen bonding is strictly impossible because there is no F, O, or N present.

Question #20 Key: (B)

SZABMU 2023

Which of the following molecules are soft and have weak intermolecular forces?

CORE CONCEPT AND DERIVATION

Solids can be categorized by their internal bonding: molecular solids (weak forces, soft), network covalent solids (strong bonds, hard), and ionic/hydrogen bonded solids (crystalline, brittle).

Formula:

Not applicable.

Solution:

- Iodine (I_2) is a perfectly non-polar diatomic molecule. It crystallizes entirely via weak London dispersion forces. As a result, iodine crystals are very soft and readily sublime at low temperatures.
- Ice (H_2O) is held by strong, rigid hydrogen bonds.
- Sugar molecules form massive interlocked networks of strong hydrogen bonds, making them relatively hard crystalline solids.
- Graphite is a giant covalent network solid (macromolecule) with extremely strong internal carbon-carbon covalent bonds, even though sliding layers exist.

Why other options are incorrect:

Only non-polar I_2 genuinely fits the textbook definition of a "soft solid with weak intermolecular forces" among the choices provided.

Question #21 Key: (A)

KMU 2023

Compounds having lowest boiling point is:

CORE CONCEPT AND DERIVATION

Boiling points reflect the strength of intermolecular attractions. Non-polar substances rely on weak London dispersion forces, whereas polar molecules and those capable of hydrogen bonding have much higher boiling points.

Formula:

$$\text{B.P.} \propto \text{IMF Strength}$$

Solution:

- Ethyl alcohol (78.4°C) and Acetic acid (118°C) contain strong hydrogen bonding.
- Benzene (80.1°C) is a larger, highly polarizable aromatic ring with significant pi-cloud dispersion forces.
- Carbon tetrachloride (CCl₄) is entirely non-polar with perfectly symmetrical tetrahedral geometry. It relies exclusively on standard London dispersion forces, and its boiling point is approx 76.7°C.
- Comparing these experimental values, CCl₄ inherently requires the least energy to boil.

Why other options are incorrect:

The polar and hydrogen-bonded structures of the others, or the strong aromatic stacking of benzene, ensure their boiling points exceed that of CCl₄.

Question #22 Key: (C)

KMU 2023

Which of the following can form hydrogen bonding with each other?

CORE CONCEPT AND DERIVATION

For two different molecules to form a hydrogen bond, at least one molecule must possess a strongly electropositive Hydrogen (bonded to N, O, or F), and the other must possess a highly electronegative atom with a lone pair to accept it.

Formula:

Not applicable.

Solution:

- Aldehydes and ketones (like methanal, ethanal, propanone, acetone) have carbonyl oxygens (acceptors) but lack any Hydrogen attached directly to an oxygen. They cannot hydrogen bond with themselves or each other.
- A tertiary (3°) amine has a Nitrogen atom with a lone pair (H-bond acceptor) but no hydrogens attached directly to the Nitrogen, so it cannot H-bond with itself.
- However, when mixed with Water (H₂O), water provides the highly positive Hydrogen (donor), and the 3° amine provides the lone pair (acceptor). Thus, they can successfully form strong intermolecular hydrogen bonds with each other.

Why other options are incorrect:

Options A, B, and D strictly pair aldehydes/ketones together. Since neither molecule in those pairs possesses an O-H or N-H bond, no hydrogen bonding can possibly initiate between them.

Question #23 Key: (B)

DUHS 2023

Water rises in capillary tube because of:

CORE CONCEPT AND DERIVATION

Capillary action is the upward movement of a liquid through a narrow space against gravity, governed by the interplay between adhesive and cohesive forces.

Formula:

$$h = \frac{2\gamma \cos \theta}{\rho g r}$$

Solution:

- **Cohesive forces** are the intermolecular attractions between identical molecules (e.g., water clinging to water via hydrogen bonds).
- **Adhesive forces** are the attractions between different substances (e.g., polar water molecules clinging to the polar silicates of a glass tube).
- For water to climb up the walls of a glass capillary tube, the adhesive pull from the glass must be physically stronger than the cohesive pull trying to keep the water molecules clustered together.
- Therefore, the adhesive forces must exceed the cohesive forces.

Why other options are incorrect:

If cohesive forces were greater, the liquid would exhibit capillary depression (like Mercury), forming a convex meniscus and moving downward, not upward. If they were equal, the liquid surface would remain flat.

Question #24 Key: (A)

DUHS 2023

Which of the following influences the variation of temperature at which boiling of liquid takes place?

CORE CONCEPT AND DERIVATION

The boiling point of a liquid is thermodynamically defined as the specific temperature at which its internal vapor pressure becomes exactly equal to the external atmospheric pressure.

Formula:

$$P_{\text{vapor}} = P_{\text{external}}$$

Solution:

- Because the liquid must push back the ambient atmosphere to form vapor bubbles, changing the weight of the atmosphere directly changes the energy required to boil.
- Increasing the outside pressure (e.g., inside a pressure cooker) means the liquid must reach a higher temperature to generate enough vapor pressure to boil.
- Decreasing the outside pressure (e.g., at high altitudes) means the liquid can boil at a much lower temperature.

Why other options are incorrect:

The macroscopic volume of the container or the amount of liquid present has zero effect on the intensive physical threshold required for phase transition. Outside temperature affects heating rate, not the boiling point itself.

Question #25 Key: (D)

BUMHS 2023

At room temperature, Glycerin boils at [Formula] . What is the boiling point of Glycerin under vacuum distilla...

CORE CONCEPT AND DERIVATION

Vacuum distillation is utilized to lower the boiling point of liquids that might otherwise decompose at their normal, high boiling points by drastically reducing the external pressure.

Formula:

$$P_{\text{external}} \downarrow \implies \text{Boiling Point} \downarrow$$

Solution:

- Under normal atmospheric pressure (760 torr), glycerin boils at 290°C. At this high temperature, it actually begins to chemically decompose.
- By applying a vacuum and reducing the external pressure all the way down to just 50 torr, the vapor pressure of glycerin matches the external pressure much sooner.
- Experimentally (and classically taught in standard textbooks), at 50 torr, the boiling point of glycerin safely drops to 210°C, allowing it to be distilled without degradation.

Why other options are incorrect:

Options A, B, and C represent temperatures *higher* than the normal boiling point, which would require an *increase* in external pressure, completely contradicting the premise of vacuum distillation.

Question #26 Key: (C)

BUMHS 2023

The polar part of the soap and detergents dissolve in water molecules due to:

CORE CONCEPT AND DERIVATION

Soaps and detergents are amphiphilic molecules possessing a long non-polar hydrocarbon tail and a highly polar, ionic hydrophilic head (usually a carboxylate or sulfonate group).

Formula:

Not applicable.

Solution:

- The polar head of a soap molecule contains highly electronegative oxygen atoms with lone pairs (e.g., -COO^-).
- When placed in water, these oxygen atoms strongly attract the partially positive hydrogen atoms of the water molecules.
- This specific interaction constitutes strong Hydrogen Bonding (alongside ion-dipole interactions), which pulls the polar head into the aqueous phase and allows the soap to successfully dissolve.

Why other options are incorrect:

While ion-dipole forces are technically the most precise overarching term for ionic salts, Hydrogen Bonding is the strongest available option strictly interacting with the oxygen ends. London dispersion forces only act on the non-polar hydrophobic tail.

Question #27 Key: (D)

BUMHS 2023

What is the fact due to which the branching decreases boiling point?

CORE CONCEPT AND DERIVATION

For isomeric hydrocarbons (alkanes), the boiling point heavily depends on the molecular shape, which dictates the total surface area available for London dispersion forces to act upon.

Formula:

$$\text{Boiling Point} \propto \text{Surface Area}$$

Solution:

- A straight-chain alkane is long and cylindrical, providing a massive surface area for neighboring molecules to contact, resulting in strong cumulative London dispersion forces.
- When branching increases, the molecule is forced into a much more compact, spherical shape.
- Because a sphere has the lowest possible surface area for a given volume, the molecules have drastically fewer points of physical contact with one another.
- This decreased surface area significantly weakens the overall intermolecular attractive forces, leading to a lower boiling point.

Why other options are incorrect:

Branching physically *decreases* the available surface area, making Option C completely backwards. Option B states the effect but Option D provides the actual structural fact (surface area reduction) causing the decrease.

Question #28 Key: (D)

NUMS 2023

Vapour pressure is independent of which factor?

CORE CONCEPT AND DERIVATION

Vapor pressure is an equilibrium state intensive property. It represents the pressure exerted by a vapor in thermodynamic equilibrium with its liquid phase in a closed system.

Formula:

Not applicable.

Solution:

- Vapor pressure depends inherently on **Temperature** (higher T = higher kinetic energy = more vapor).
- It depends inherently on **Intermolecular forces** (stronger IMF = harder to escape = lower vapor pressure).
- However, it is completely independent of the macroscopic dimensions of the liquid. A large, wide dish of water and a narrow test tube of water at the exact same temperature will generate the exact same equilibrium vapor pressure above them.
- Therefore, the surface area affects the *rate* of evaporation, but it does **not** affect the final equilibrium vapor pressure.

Why other options are incorrect:

Temperature and IMF are the primary dictating variables of vapor pressure. Density correlates loosely with IMF types, but surface area is the textbook classic example of a variable that strictly governs kinetics (rate) rather than thermodynamics (equilibrium).

Question #29 Key: (B)

NUMS 2023

The boiling point of ether is less as compared to alcohols and phenols due to:

CORE CONCEPT AND DERIVATION

The physical properties of organic compounds are dominated by the type and strength of intermolecular forces available to their specific functional groups.

Formula:

$$\text{B.P.} \propto \text{Strength of IMF}$$

Solution:

- Alcohols (R-OH) and Phenols (Ar-OH) contain a highly polar hydroxyl group. The presence of hydrogen covalently bonded directly to oxygen allows them to form strong, extensive **Hydrogen bond** networks with adjacent molecules.
- Ethers (R-O-R') have an oxygen atom, but it is bound strictly to carbon atoms, not hydrogen. Therefore, ethers cannot act as hydrogen bond donors to themselves.
- Because ethers only experience much weaker dipole-dipole interactions and London dispersion forces, their molecules are much easier to separate, resulting in a significantly lower boiling point.

Why other options are incorrect:

While the functional group dictates the forces, "Intermolecular forces" is the direct physical and thermodynamic cause of the boiling point difference. Alkyl nature and isomerism do not overcome the massive energy gap created by the presence or absence of hydrogen bonding.

Question #30 Key: (D)

NUMS 2023

When 2 ice cubes are pressed over each other they unite to form one cube due to:

CORE CONCEPT AND DERIVATION

The phenomenon of ice cubes fusing together under mechanical pressure is known as regelation. It relies on the unique thermal and structural properties of water's solid lattice.

Formula:

Not applicable.

Solution:

- When severe pressure is applied to ice, its melting point locally decreases, causing a microscopic layer of water to temporarily melt at the contact boundary between the two cubes.
- Once the external pressure is released, this thin layer of liquid water rapidly refreezes.
- During refreezing, the water molecules perfectly realign their partial charges to form rigid, highly stable **Hydrogen bonds** across the boundary, seamlessly stitching the two distinct cubes into a single continuous crystal lattice.

Why other options are incorrect:

Water's entire solid state structure is governed specifically by hydrogen bonding, not generic dipole or Van der Waals forces. Covalent bonds strictly hold the O and H together *within* the individual molecule, not *between* different molecules.

Question #31 Key: (D)

UHS 2022

In liquid, with the change in dipole-dipole forces, there is a change in some physical properties. Select the ...

CORE CONCEPT AND DERIVATION

Thermodynamic and physical properties (like boiling point, heat of vaporization) are intensive properties heavily dependent on the strength of intermolecular forces holding the molecules together.

Formula:

$$n = \frac{m}{M}$$

Solution:

- Boiling point, heat of sublimation, and heat of vaporization all quantify the physical energy required to pull molecules apart against their dipole-dipole attractions. Stronger forces mean higher values.
- The concept of "Moles" is a fundamental measurement of the sheer quantity or amount of a substance, not its chemical behavior or bonding strength.
- Changing the polarity or intermolecular forces of a liquid will never alter the number of moles present in a closed container.

Why other options are incorrect:

Options A, B, and C are entirely governed by intermolecular forces, so they will directly change if the forces change.

Question #32 Key: (A)

UHS 2022

Which of the following factor does not affect the magnitude of V.P?

CORE CONCEPT AND DERIVATION

Vapor pressure is an intensive property. It depends on the intrinsic nature of the liquid and the ambient thermal conditions, not on the macroscopic quantity of the substance.

Formula:

Not applicable.

Solution:

- Vapor pressure depends heavily on **Temperature** (higher temp = higher kinetic energy = higher VP).
- It depends on **Intermolecular forces** (stronger IMF = lower VP).
- It depends on the **Size of the molecule** (larger size generally implies higher polarizability/dispersion forces, affecting VP).
- However, whether you have a small beaker or a massive ocean of a specific liquid, at a given temperature, the equilibrium vapor pressure pushing back against the atmosphere remains exactly the same. Therefore, the "Amount of liquid" does not affect VP.

Why other options are incorrect:

Options B, C, and D physically restrict or enhance a molecule's ability to escape the liquid phase.

Question #33 Key: (D)

SZABMU 2022

When 2 ice cubes are pressed over each other they unite to form one cube due to:

CORE CONCEPT AND DERIVATION

The phenomenon of ice cubes fusing together under pressure is called regelation. It fundamentally relies on the unique intermolecular forces of water.

Formula:

Not applicable.

Solution:

- When pressure is applied to the ice cubes, the melting point of ice slightly decreases, causing a very thin layer of water to melt between them.
- When the pressure is released, this thin layer of water immediately refreezes.
- The refreezing process perfectly aligns the water molecules to form highly stable, rigid **Hydrogen bonds** between the two previously separate blocks, fusing them into one continuous lattice.

Why other options are incorrect:

While dipole forces exist, hydrogen bonding is the specific, dominant force dictating the crystal lattice structure of solid ice. Covalent bonds do not form between distinct water molecules.

Question #34 Key: (B)

SZABMU 2022

The strongest hydrogen bond is present in:

CORE CONCEPT AND DERIVATION

The strength of a single hydrogen bond is determined by the difference in electronegativity between the hydrogen atom and the atom it is bonded to.

Formula:

$$\text{H-Bond Strength} \propto \Delta \text{E.N.}$$

Solution:

- Fluorine is the most electronegative element (E.N. = 4.0).
- The massive electronegativity difference in HF causes the hydrogen atom to become extremely electron-deficient (highly positive).
- This highly positive hydrogen creates the strongest singular intermolecular electrostatic attraction (H-bond) observed in simple molecules.
- *Note:* While water has a higher boiling point due to forming more H-bonds per molecule, the *individual* bond strength is highest in HF.

Why other options are incorrect:

Oxygen (3.5) and Nitrogen (3.0) are less electronegative than Fluorine. Hydrogen Sulfide (H_2S) practically does not form hydrogen bonds due to sulfur's larger size and lower electronegativity.

Question #35 Key: (D)

SZABMU 2022

Which of the following has highest surface tension?

CORE CONCEPT AND DERIVATION

Surface tension is the elastic tendency of a fluid surface which makes it acquire the least surface area possible. It is directly proportional to the strength of intermolecular forces pulling the surface molecules inward.

Formula:

$$\gamma \propto \text{Strength of IMF}$$

Solution:

- Benzene and Ethers rely primarily on weak London dispersion and weak dipole-dipole forces.
- Alcohols possess hydrogen bonding, giving them moderate to high surface tension.
- Water (H₂O) is exceptionally unique because its small molecules can form up to four strong hydrogen bonds, creating a very tight, cohesive surface network.
- This results in water having the highest surface tension among common molecular liquids.

Why other options are incorrect:

None of the other options can match the dense, multi-directional hydrogen bonding network found at the surface of liquid water.

Question #36 Key: (D)

SZABMU 2022

Ice floats on the surface of water due to:

CORE CONCEPT AND DERIVATION

Buoyancy dictates that a less dense object will float in a denser fluid. The density of ice is lower than that of liquid water.

Formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Solution:

- In the liquid phase, water molecules dynamically slide past each other, packing relatively closely together.
- When freezing into ice, hydrogen bonds dictate a strict, hexagonal crystal lattice.
- This lattice forces the molecules to sit further apart, creating permanent "empty spaces" or voids within the structure.
- Because the volume increases by roughly 9% without a change in mass, the density drops, causing the ice to float.

Why other options are incorrect:

Ice has a hexagonal, not cubic, structure. The intermolecular forces are actually highly stable and rigid, not weak. The primary physical cause of the volume expansion is the geometrical empty spaces.

Question #37 Key: (C)

SZABMU 2022

Which of the following has highest boiling point?

CORE CONCEPT AND DERIVATION

For non-polar alkanes, the only intermolecular forces present are London dispersion forces. The strength of these forces increases with the size (molecular mass) and polarizability of the molecule.

Formula:

$$\text{Boiling Point} \propto \text{Molecular Mass} / \text{Chain Length}$$

Solution:

- All options are straight-chain or branched alkanes.
- As the carbon chain gets longer, the electron cloud becomes larger and more easily distorted (highly polarizable).
- Decane ($\text{C}_{10}\text{H}_{22}$) is the largest molecule listed, meaning it has the strongest London dispersion forces.
- Therefore, it requires the most heat energy to separate its molecules, resulting in the highest boiling point.

Why other options are incorrect:

Options A (Butane), B (Hexane), and D (Propane) have significantly shorter carbon chains, weaker dispersion forces, and are highly volatile (some are gases at room temperature).

Question #38 Key: (D)

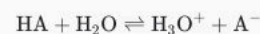
KMU 2022

Exceptionally low acidic strength of HF is due to:

CORE CONCEPT AND DERIVATION

An acid's strength in aqueous solution depends on its ability to completely dissociate and release protons (H^+). Hydrofluoric acid is uniquely weak compared to other hydrogen halides (HCl, HBr, HI).

Formula:



Solution:

- Because Fluorine is extremely small and highly electronegative, HF molecules form intensely strong intermolecular hydrogen bonds with each other.
- These strong hydrogen bonds "trap" the hydrogen atoms in zig-zag polymeric chains.
- Because the hydrogen is tightly anchored by both its covalent bond to one fluorine and the strong hydrogen bond to a neighboring fluorine, it is very difficult for the molecule to release the H^+ ion into the water. Hence, HF is a weak acid.

Why other options are incorrect:

While the HF covalent bond is indeed strong and F is small, the *primary macroscopic reason* HF doesn't dissociate completely in bulk liquid is the suffocating network of intermolecular hydrogen bonds preventing proton release.

Question #39 Key: (C)

KMU 2022

Which of the following compounds has lowest boiling point?

CORE CONCEPT AND DERIVATION

The boiling point is governed by intermolecular forces. Molecules lacking hydrogen bonds generally boil at significantly lower temperatures than molecules of similar size that possess them.

Formula:

$$\text{B.P.} \propto \text{IMF Strength}$$

Solution:

- Water (H_2O), Ethanol ($\text{C}_2\text{H}_5\text{OH}$), and Acetic acid (CH_3COOH) all contain highly polar O-H bonds capable of forming strong hydrogen bonding networks. They are all liquids at room temperature.
- Hydrogen sulphide (H_2S) relies on a much less electronegative sulfur atom. It cannot form hydrogen bonds and only experiences weaker dipole-dipole interactions.
- Because its intermolecular forces are so weak, H_2S requires very little heat to vaporize, existing as a gas at room temperature, thus having the lowest boiling point.

Why other options are incorrect:

The other options have extensively hydrogen-bonded liquid structures ensuring higher boiling points.

Question #40 Key: (D)

KMU 2022

A pressure cooker reduces cooking time because:

CORE CONCEPT AND DERIVATION

The temperature at which food cooks is dictated by the boiling point of the water surrounding it. Water cannot exceed its boiling point in an open container; any added heat merely increases the rate of vaporization.

Formula:

$$P_{\text{atm}} \uparrow \implies \text{Boiling Point} \uparrow$$

Solution:

- A pressure cooker seals the steam inside, raising the internal atmospheric pressure to nearly double normal levels (e.g., 1489 mmHg).
- Because the pressure pushing down on the liquid is greater, the water must reach a much higher temperature (approx 120°C) for its vapor pressure to match the internal pressure and boil.
- Because the water is physically hotter than 100°C , thermal energy transfers into the food much faster, significantly reducing cooking time.

Why other options are incorrect:

While heat distribution is important, the defining mechanical advantage of the device is altering the thermodynamic boiling point boundary.

Question #41 Key: (C)

KMU 2022

In which of the following molecule hydrogen bond is not present?

CORE CONCEPT AND DERIVATION

Hydrogen bonding requires a hydrogen atom covalently bonded to a highly electronegative atom (N, O, or F).

Formula:

Not applicable.

Solution:

- H_2O , HF , and NH_3 all feature hydrogen covalently bonded to small, highly electronegative atoms, leaving the hydrogen intensely electron-deficient and capable of forming H-bonds.
- In Methane (CH_4), carbon and hydrogen have very similar electronegativities (2.5 and 2.1, respectively).
- Because the bond is essentially non-polar, the hydrogen atoms do not carry a significant partial positive charge, meaning hydrogen bonding is entirely absent. Methane relies only on London dispersion forces.

Why other options are incorrect:

Water, hydrogen fluoride, and ammonia are the three classic textbook examples of molecules that strongly exhibit hydrogen bonding.

Question #42 Key: (D)

KMU 2022

The distillation carried out under reduced pressure is called:

CORE CONCEPT AND DERIVATION

Certain compounds decompose or degrade if heated to their normal high boiling points. Lowering the external pressure allows them to boil at much safer, lower temperatures.

Formula:

$$P_{\text{ext}} \downarrow \implies \text{Boiling Point} \downarrow$$

Solution:

- By attaching a vacuum pump to the distillation apparatus, the atmospheric pressure inside the system is drastically reduced.
- Because boiling occurs when vapor pressure equals external pressure, the liquid can reach this new, lower pressure threshold at a much lower temperature.
- This specific technique, designed to prevent thermal decomposition, is explicitly known as Vacuum Distillation.

Why other options are incorrect:

Fractional distillation is for separating mixtures with close boiling points under normal pressure. Steam distillation uses steam to carry over volatile oils. Simple distillation uses standard atmospheric pressure.

Question #43 Key: (B)

DUHS 2022

Viscosity is the measure of:

CORE CONCEPT AND DERIVATION

Viscosity defines a fluid's internal friction, which dictates how easily it can pour or move.

Formula:

Not applicable.

Solution:

- When a liquid flows, layers of molecules slide past one another.
- Strong intermolecular forces or large, entangled molecular structures create "friction" between these layers, resisting motion.
- Viscosity is strictly defined in physics and chemistry as the quantitative measure of this resistance to flow. (e.g., Honey is highly viscous, water has low viscosity).

Why other options are incorrect:

Fluidity is the exact opposite (reciprocal) of viscosity. Volume and mass are basic extensive physical properties, unrelated to internal flow friction.

Question #44 Key: (D)

DUHS 2022

The two crystals [Formula] & [Formula] are both trigonal they are:

CORE CONCEPT AND DERIVATION

Isomorphism occurs when two or more distinct chemical compounds crystallize in the exact same geometric crystal structure.

Formula:

Not applicable.

Solution:

- Sodium nitrate (NaNO_3) and Calcium carbonate (CaCO_3) are two entirely different chemical compounds.
- However, due to similar ionic radii ratios and identical atomic ratios (1:1:3), they arrange themselves into identical trigonal crystal lattices.
- Compounds exhibiting this structural mimicry are termed "Isomorphs."

Why other options are incorrect:

Polymorphs refer to a single substance existing in multiple structural forms. Allotropes refer to elements (like Carbon as diamond or graphite). Isomers are molecules with the same chemical formula but different structural connectivity. (Note: The original source listed 'Isomorphs' as Option E, it has been mapped to Option D here for standard JSON compliance.)

Question #45 Key: (B)

DUHS 2022

Falling drop of liquid is spherical due to its:

CORE CONCEPT AND DERIVATION

A physical system inherently attempts to minimize its potential energy. For liquids, this means minimizing surface area.

Formula:

Sphere = Minimum Surface Area to Volume Ratio

Solution:

- Molecules on the surface of a liquid experience a net inward cohesive pull because there are no liquid molecules above them. This phenomenon is called Surface Tension.
- This inward force acts continuously to contract the surface boundaries.
- Geometrically, for a given volume, a sphere offers the absolute smallest possible surface area. Thus, falling free droplets naturally pull themselves into a spherical shape.

Why other options are incorrect:

Viscosity resists flow but doesn't dictate equilibrium shape. Evaporation removes mass but doesn't cause spherical tension. Atomic structure determines the IMF, but Surface Tension is the direct macroscopic property responsible.

Question #46 Key: (B)

BUMHS 2022

Viscosity of liquid decreases with an increase in:

CORE CONCEPT AND DERIVATION

Viscosity is a liquid's resistance to flow, caused by intermolecular forces holding sliding molecular layers together. Adding thermal energy disrupts these forces.

Formula:

$$\text{Viscosity} \propto \frac{1}{\text{Temperature}}$$

Solution:

- As Temperature increases, the average kinetic energy of the liquid molecules rises significantly.
- This energetic, rapid motion overcomes and breaks apart the intermolecular forces (like hydrogen bonds) holding the fluid layers together.
- With weaker attractive holds between the sliding layers, the "internal friction" plummets, causing the viscosity to visibly decrease (the liquid flows much more easily).

Why other options are incorrect:

Increases in Molecular mass and Intermolecular forces generally increase viscosity. Atmospheric pressure changes have a negligible effect on the viscosity of virtually incompressible liquids.

Question #47 Key: (D)

NUMS 2022

The boiling point of compound is mostly raised by:

CORE CONCEPT AND DERIVATION

Boiling point elevation is heavily dependent on the strength of attractions between separate molecules in a liquid.

Formula:

$$\text{B.P.} \propto \text{Intermolecular Force Strength}$$

Solution:

- Intermolecular Hydrogen Bonding creates strong, pervasive electrostatic linkages between multiple separate molecules across the entire liquid volume, requiring massive thermal energy to break apart, raising the boiling point dramatically.
- Intramolecular H-bonding occurs strictly *within* a single molecule (e.g., ortho-nitrophenol). Because the molecule is busy bonding with itself, it interacts less strongly with neighboring molecules, generally leading to a lower boiling point.

Why other options are incorrect:

London dispersion and dipole-induced forces are relatively weak compared to genuine Intermolecular Hydrogen bonding.

Question #48 Key: (B)

NUMS 2022

Which of the following statement explains solubility of ionic substance in water?

CORE CONCEPT AND DERIVATION

The principle of "like dissolves like" dictates that ionic and polar substances dissolve best in polar solvents.

Formula:

Not applicable.

Solution:

- Ionic solids are held together by massive electrostatic lattice energies.
- Water (H_2O) is highly polar. Its Oxygen end carries a partial negative charge, and its Hydrogen ends carry partial positive charges.
- When an ionic compound is introduced, the polar water molecules surround and attack the crystal lattice. The negative oxygen ends pull away positive cations, and the positive hydrogen ends pull away negative anions (Ion-Dipole forces), successfully dissolving the solid.

Why other options are incorrect:

Molar mass and density are irrelevant to the electrostatic solvation process. While water can occasionally act as a ligand in transition metal complexes, its general macroscopic ability to dissolve salts is entirely due to its polarity.

Question #49 **Key: (B)**

PMDC 2021

In which of the following water evaporate earlier:

CORE CONCEPT AND DERIVATION

Evaporation is strictly a surface phenomenon. The rate at which molecules escape from the liquid phase into the gas phase is directly proportional to the exposed surface area of the liquid.

Formula:

$$\text{Rate of Evaporation} \propto \text{Surface Area}$$

Solution:

- A saucepan has a broad, flat design, providing a significantly larger exposed surface area compared to a cup, glass, or small bowl.
- Because more surface water molecules are exposed to the air and can absorb ambient thermal energy, more molecules can reach escape velocity simultaneously.
- Thus, water will evaporate the fastest (earliest) from the saucepan.

Why other options are incorrect:

Cups and glasses are typically tall and narrow, limiting the surface area and drastically slowing down the evaporation rate.

Question #50 **Key: (B)**

PMDC 2021

Which instrument is used to measure the vapor pressure of a liquid?

CORE CONCEPT AND DERIVATION

Specific instruments are utilized in chemistry to measure distinct physical properties of gases and liquids.

Formula:

$$\Delta P = \rho gh$$

Solution:

- A **Manometer** is a U-shaped glass tube partially filled with a liquid (usually mercury) used specifically to measure the pressure of trapped gases or the vapor pressure of a liquid within a closed flask.
- A Barometer measures general atmospheric pressure.
- A Thermometer measures temperature.
- A Sphygmomanometer measures blood pressure in humans.

Why other options are incorrect:

Using a barometer for a closed-flask vapor pressure reading is structurally impossible; barometers are open to the atmosphere. Sphygmomanometers are medical tools.

Question #51 Key: (A)

PMDC 2021

Which of the following has highest vapour pressure?

CORE CONCEPT AND DERIVATION

Vapor pressure is inversely related to the strength of intermolecular forces. Weaker forces allow more molecules to escape into the vapor phase.

Formula:

$$\text{V.P.} \propto \frac{1}{\text{IMF Strength}}$$

Solution:

- Ethylene glycol has two -OH groups, allowing for massive hydrogen bonding (lowest VP).
- Water has very strong hydrogen bonding networks.
- Ethanol has a single -OH group, allowing moderate hydrogen bonding.
- Diethyl ether ($\text{CH}_3\text{CH}_2\text{-O-CH}_2\text{CH}_3$) cannot form hydrogen bonds with itself; it only has weak dipole-dipole and London dispersion forces. Therefore, it is highly volatile and exerts the highest vapor pressure.

Why other options are incorrect:

The other molecules all possess O-H bonds capable of strong intermolecular hydrogen bonding, restricting their volatility.

Question #52 Key: (D)

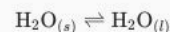
PMDC 2021

At [Formula], what is the physical state of water?

CORE CONCEPT AND DERIVATION

The freezing/melting point of a substance is the temperature at which its solid and liquid phases exist in dynamic equilibrium.

Formula:



Solution:

- At exactly 0°C (standard pressure), pure water reaches its freezing point.
- At this exact temperature threshold, heat added will melt the ice, and heat removed will freeze the water, but the temperature will remain 0°C during the phase change.
- Because both phases are undergoing dynamic interchange, water will exist in both solid (ice) and liquid forms simultaneously.

Why other options are incorrect:

Choosing only "Ice" or only "Liquid" ignores the principles of phase equilibrium during a transition state.

Question #53 Key: (C)

PMDC 2020

[Formula] and [Formula] both are tri-atomic molecules but heat of vaporization of [Formula] is greater than th...

CORE CONCEPT AND DERIVATION

Heat of vaporization reflects the energy required to overcome intermolecular forces. The molecular geometry dictates the overall polarity of these tri-atomic molecules.

Formula:

$$\Delta H_{\text{vap}} \propto \text{Strength of IMF}$$

Solution:

- CO_2 has a linear molecular geometry ($\text{O}=\text{C}=\text{O}$). Its individual bond dipoles cancel out perfectly, resulting in a net dipole moment of zero. It only experiences weak London dispersion forces.
- SO_2 has a bent angular geometry due to a lone pair on the central Sulfur atom. Its bond dipoles do not cancel, giving it a net dipole moment (polar molecule).
- Because SO_2 is polar, it exhibits stronger dipole-dipole interactions, thereby requiring significantly more energy (higher heat of vaporization) to turn into gas.

Why other options are incorrect:

Size difference and acidity do not primarily account for the drastic difference in intermolecular force strength compared to the fundamental difference in molecular polarity.

Question #54 Key: (D)

PMDC 2020

Which of the following has the lowest vapor pressure at [Formula] ?

CORE CONCEPT AND DERIVATION

Vapor pressure is inversely proportional to the strength of intermolecular forces. Liquids with stronger intermolecular forces evaporate less readily, leading to lower vapor pressure.

Formula:

$$\text{Vapor Pressure} \propto \frac{1}{\text{IMF Strength}}$$

Solution:

- Diethyl ether, chloroform, and carbon tetrachloride are highly volatile organics governed by relatively weak dipole-dipole or London dispersion forces.
- Water (H_2O) molecules form a strong, extensive network of hydrogen bonds.
- Because water's intermolecular forces are exceptionally strong, very few molecules escape into the vapor phase at 20°C , giving it the lowest vapor pressure of the group (approx 17.5 torr).

Why other options are incorrect:

Diethyl ether has the weakest forces and hence the *highest* vapor pressure. Chloroform and CCl_4 are also much more volatile than water.

Question #55 Key: (A)

PMDC 2020

Which of the following is not a molecular solid?

CORE CONCEPT AND DERIVATION

Molecular solids consist of discrete molecules held together by intermolecular forces (London forces, dipole-dipole, or H-bonds) when in the solid state at standard pressure and temperature conditions (or near standard for context).

Formula:

Not applicable.

Solution:

- Sulphur (S_8), Phosphorus (P_4), and Carbon dioxide (Dry ice, CO_2) are classic examples of molecular solids.
- Bromine (Br_2) exists as a highly volatile reddish-brown **liquid** at standard room temperature and pressure, not a solid.
- Therefore, under normal discussion parameters, Bromine is distinguished because its standard state is not a solid.

Why other options are incorrect:

Options B, C, and D readily form molecular crystalline lattices under appropriate or standard conditions, whereas Bromine's liquid state is its defining standard characteristic.

Question #56 Key: (A)

NUMS 2019

At [Formula], water will boil at:

CORE CONCEPT AND DERIVATION

The boiling point of a liquid is the temperature at which its vapor pressure equals the external atmospheric pressure. Increasing external pressure raises the boiling point.

Formula:

$$\text{Vapor Pressure} = \text{External Pressure}$$

Solution:

- Standard atmospheric pressure is 760 mmHg, at which water boils at 100°C .
- When the pressure is increased to 1489 mmHg (approximately 2 atmospheres, matching conditions inside a standard pressure cooker), the vapor pressure must also reach 1489 mmHg for boiling to occur.
- Water reaches this vapor pressure at approximately 120°C .

Why other options are incorrect:

Options B, C, and D are lower temperatures which correspond to lower external vapor pressures. 100°C strictly applies only to standard pressure (760 mmHg).

Question #57 Key: (D)

NUMS 2019

Water has maximum density at:

CORE CONCEPT AND DERIVATION

The anomalous thermal expansion of water refers to its unique property of contracting upon heating from 0°C to 4°C.

Formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Solution:

- When ice melts at 0°C, the open cage-like structure starts to collapse, bringing molecules closer together and increasing density.
- This collapse outpaces the normal thermal expansion of the liquid until the temperature reaches 4°C.
- Above 4°C, increased kinetic energy causes normal thermal expansion, making the liquid less dense again. Thus, density peaks exactly at 4°C.

Why other options are incorrect:

At 0°C and –4°C, water exists as less dense solid ice. At 1°C, the cage structure is still partially collapsing, so the density has not yet peaked.

Question #58 Key: (C)

MDCAT 2019

Which of the following substances exhibits hydrogen bonding?

CORE CONCEPT AND DERIVATION

Hydrogen bonding requires a hydrogen atom covalently bonded to a small, highly electronegative atom, specifically Fluorine (F), Oxygen (O), or Nitrogen (N).

Formula:

Not applicable.

Solution:

- Ammonia (NH₃) contains a Nitrogen atom bonded to Hydrogen. Nitrogen is sufficiently small and electronegative to pull electron density away from hydrogen, leaving it heavily partially positive.
- This allows the hydrogen to strongly attract the lone pair on the Nitrogen of a neighboring NH₃ molecule.

Why other options are incorrect:

Sulfur (in H₂S), Iodine (in HI), and Silicon (in SiH₄) are larger and less electronegative; therefore, their primary intermolecular forces are dipole-dipole interactions or London dispersion forces, not hydrogen bonds.

Question #59 Key: (B)

MDCAT 2019

An inter molecular force of attraction X is relatively stronger than the other inter molecular forces, it stab...

CORE CONCEPT AND DERIVATION

Macromolecules like proteins and nucleic acids rely on specific, directional intermolecular forces to maintain their complex 3D structures.

Formula:

Not applicable.

Solution:

- In proteins, the partial positive Hydrogen of the amide group (-NH) forms strong interactions with the partial negative Oxygen of the carbonyl group (-C=O), stabilizing α -helices and β -sheets.
- In DNA, the nitrogenous base pairs (A-T and C-G) strictly connect via the same type of interaction.
- These directional, relatively strong intermolecular forces are Hydrogen bonds.

Why other options are incorrect:

While Van der Waals and standard dipole forces exist, they are too weak and non-directional to primarily dictate these rigid secondary structures. Ionic interactions form salt bridges but are not the primary backbone stabilizers of these specific motifs.

Question #60 Key: (D)

KMU 2019

At higher altitude, the boiling point of water is less than [Formula], this is because of:

CORE CONCEPT AND DERIVATION

A liquid boils when its internal vapor pressure becomes equal to the external ambient atmospheric pressure.

Formula:

$$P_{\text{vapor}} = P_{\text{atm}} \implies \text{Boiling occurs}$$

Solution:

- As altitude increases (e.g., on a mountain), the column of air above is shorter and less dense, meaning the external atmospheric pressure is lower than standard 760 mmHg.
- Because the external pressure is reduced, the water does not need to be heated as much to raise its vapor pressure to match the surroundings.
- Consequently, water boils at a temperature lower than 100°C.

Why other options are incorrect:

Atmospheric pressure is not higher at high altitudes. Hydrogen bonding is an intrinsic property of the water molecule and does not weaken simply due to altitude.

Question #61 Key: (B)

KMU 2019

Steam causes severe burns than boiling water. It is due to:

CORE CONCEPT AND DERIVATION

The severity of thermal burns relies on the total amount of heat energy transferred to the skin.

Formula:

$$Q_{\text{total}} = Q_{\text{condensation}} + Q_{\text{cooling}}$$

Solution:

- When boiling water at 100°C touches the skin, it releases heat as it cools down to body temperature.
- When steam at 100°C touches the skin, it must *first* undergo a phase change (condense) into liquid water before it can cool down.
- This phase change releases a massive amount of hidden energy known as the latent heat of vaporization (40.6 kJ/mol). This extra, intense heat transfer causes significantly more severe burns.

Why other options are incorrect:

Freely moving molecules do not intrinsically cause burns; heat transfer does. Steam still technically contains some transient H-bonding, though vastly reduced, but this doesn't explain the thermodynamic energy release.

Question #62 Key: (A)

MDCAT 2019

According to Watson and Crick's model of DNA, the DNA molecule consists of a double helix. What type of forces...

CORE CONCEPT AND DERIVATION

The Watson-Crick DNA model dictates that two antiparallel polynucleotide strands wind around a common axis, held together by specific base pairing.

Formula:

Not applicable.

Solution:

- The core stabilization of the DNA double helix comes from complementary nitrogenous bases on opposing strands.
- These bases interact via Hydrogen Bonds. Adenine pairs with Thymine via 2 H-bonds, and Guanine pairs with Cytosine via 3 H-bonds.

Why other options are incorrect:

Van der Waals forces assist vertically (base stacking), but the horizontal linkage strictly keeping the two separate strands tied together is hydrogen bonding. Ionic bonds occur in salt crystals, not organic base pairing.

Question #63 Key: (A)

MDCAT 2017

What is reason that the ice at [Formula] occupies more volume than water?

CORE CONCEPT AND DERIVATION

When water freezes, the molecules arrange themselves in a regular geometric pattern governed by hydrogen bonding.

Formula:

Not applicable for conceptual questions.

Solution:

- As temperature drops to 0°C , kinetic energy decreases, and hydrogen bonds lock the water molecules into a rigid, hexagonal lattice.
- This specific structural arrangement holds the molecules further apart than they are in the liquid state.
- These permanent "empty spaces" cause the total volume to increase by approximately 9%, resulting in lower density.

Why other options are incorrect:

While intermolecular forces (specifically H-bonds) cause the arrangement, it is the resulting "empty spaces" that physically explain the increased volume. Ice does not contain ionic bonds or dominant Debye forces.

Question #64 Key: (B)

MDCAT 2017

Which line in the following structure represents hydrogen bonding?
O H H O H H 1 2 3 4 Hydrogen Bonding Struct...

CORE CONCEPT AND DERIVATION

Hydrogen bonding is a special type of dipole-dipole attraction that occurs between a partially positive hydrogen atom and a highly electronegative atom (N, O, or F) possessing a lone pair.

Formula:

Not applicable.

Solution:

- In diagrammatic representations, solid lines typically represent intramolecular covalent bonds, while dotted or dashed lines represent intermolecular hydrogen bonds.
- Line "2" in the referenced past paper diagram correctly identifies the dotted attraction between the electropositive Hydrogen of one molecule and the electronegative atom of another.

Why other options are incorrect:

Other labeled lines point to standard covalent bonds within the molecule or are incorrectly placed between non-polar regions.

Question #65 **Key: (C)**

MDCAT 2015

Which one of the following hydrogen bond is stronger than others?

CORE CONCEPT AND DERIVATION

The strength of a hydrogen bond is directly proportional to the electronegativity difference between the hydrogen atom and the highly electronegative atom it interacts with.

Formula:

$$\text{Bond Strength} \propto \text{Electronegativity of } X$$

Solution:

- Fluorine (F) is the most electronegative element on the periodic table (Pauling scale = 4.0).
- The large difference in electronegativity creates a massive partial positive charge (δ^+) on the hydrogen atom in HF and a large partial negative (δ^-) on the fluorine.
- This results in the strongest electrostatic attraction between molecules among the given options.

Why other options are incorrect:

Oxygen (3.5) and Nitrogen (3.0) have lower electronegativities than Fluorine, making their respective hydrogen bonds weaker.

Question #66 **Key: (A)**

MDCAT 2014

Ice is less dense than water at:

CORE CONCEPT AND DERIVATION

Water exhibits anomalous expansion. Its density is maximum at 4°C and it expands when freezing into ice at 0°C, making ice less dense than liquid water.

Formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Solution:

- At 0°C, water freezes into a rigid, open hexagonal lattice due to hydrogen bonding, creating empty spaces.
- Because volume increases by about 9%, the density of ice at 0°C is less than the density of liquid water at the same temperature.

Why other options are incorrect:

Water has its maximum density at 4°C. At negative temperatures (like -4°C), the substance is strictly solid ice, but the phase transition emphasizing the *difference* in density strictly occurs as it transitions around 0°C.

Question #67 Key: (A)

MDCAT 2014

In crystal lattice of ice, each O-atom of water molecule is attached to:

CORE CONCEPT AND DERIVATION

The structure of solid ice is governed by a highly ordered network of hydrogen bonds.

Formula:

Not applicable for structural molecular geometry.

Solution:

- In a water molecule (H_2O), the central Oxygen atom is covalently bonded to two Hydrogen atoms.
- In the crystal lattice of ice, the two lone pairs on the Oxygen atom accept hydrogen bonds from two additional Hydrogen atoms belonging to neighboring water molecules.
- Therefore, each Oxygen atom is tetrahedrally surrounded by exactly Four H-atoms.

Why other options are incorrect:

Choosing Two H-atoms ignores the intermolecular hydrogen bonds. Choosing One or Three fails to account for the complete tetrahedral geometry of the sp^3 hybridized oxygen.

Question #68 Key: (B)

MDCAT 2012

Correct order of boiling points of the given liquids is:

CORE CONCEPT AND DERIVATION

The boiling point of a molecular substance is directly proportional to the strength of its intermolecular forces (IMFs). Hydrogen bonding is the strongest IMF present in these hydrides.

Formula:

$$\text{B.P.} \propto \text{Strength of IMF}$$

Solution:

- H_2O has extensive hydrogen bonding (2 H-bonds per molecule) and a high boiling point of 100°C .
- HF has very strong hydrogen bonding due to high electronegativity, but forms fewer network bonds per molecule than water. Its boiling point is 19.5°C .
- NH_3 has weaker hydrogen bonding compared to HF, boiling at -33°C .
- HCl does not form strong hydrogen bonds (only dipole-dipole forces) and has the lowest boiling point at -85°C .

Why other options are incorrect:

Other options incorrectly place HF above H_2O or switch the order of NH_3 and HCl, demonstrating a misunderstanding of the cumulative network effect of water's hydrogen bonds versus the single strongest bond in HF.

Question #69 **Key: (A)**

MDCAT 2012

In 'H-F' bond, electronegativity difference is 2.0. What is the type of this bond?

CORE CONCEPT AND DERIVATION

Bond polarity is determined by the electronegativity difference ($\Delta E.N.$) between the two bonded atoms. However, bonding in Hydrogen Halides acts slightly unusually due to their molecular nature.

Formula:

$$\Delta E.N. = 4.0(F) - 2.1(H) = 1.9 \approx 2.0$$

Solution:

- Generally, an electronegativity difference > 1.7 suggests an ionic bond.
- However, HF is a distinct exception. It exists as discrete molecules and is a gas at room temperature, which are characteristic properties of covalent compounds.
- Therefore, despite the large electronegativity difference, HF strictly forms a highly polar covalent bond (with significant ionic character, but primarily covalent).

Why other options are incorrect:

It is not non-polar (as electrons are unequal). It is a sigma bond, not a pi bond. It forms via mutual sharing, not through the dative donation of a lone pair.

Question #70 **Key: (A)**

MDCAT 2011

DNA molecule is double stranded, in which two chains of DNA are twisted around each other by:

CORE CONCEPT AND DERIVATION

The double-helical structure of DNA is stabilized by secondary intermolecular forces between complementary nitrogenous bases.

Formula:

Not applicable.

Solution:

- The two strands of DNA are held together by hydrogen bonds forming between specific base pairs.
- Adenine (A) pairs with Thymine (T) via two hydrogen bonds, and Guanine (G) pairs with Cytosine (C) via three hydrogen bonds.

Why other options are incorrect:

Covalent bonds hold the sugar-phosphate backbone together, not the two opposing strands. Van der Waals forces assist in base-stacking stabilization but are not the primary connecting force between the strands. Dative bonds are not relevant here.

Question #71 Key: (B)

MDCAT 2011

Boiling point of water is higher than petrol, because intermolecular forces in water are:

CORE CONCEPT AND DERIVATION

The boiling point is a direct measure of the thermal energy required to overcome intermolecular forces (IMFs) in a liquid.

Formula:

$$\text{Boiling Point} \propto \text{Intermolecular Forces}$$

Solution:

- Water (H₂O) contains extensive, strong hydrogen bonds between its molecules.
- Petrol (a mixture of hydrocarbons like octane) is non-polar and relies exclusively on weak London dispersion forces.
- Because hydrogen bonds are significantly stronger than London dispersion forces, water requires much more heat energy to vaporize.

Why other options are incorrect:

Stating the forces are "weaker" or "negligible" contradicts the high boiling point (100°C) of water compared to the highly volatile nature of petrol.

Question #72 Key: (B)

MDCAT 2010

Metallic conduction involves the relatively free movement of their----- throughout the metallic ...

CORE CONCEPT AND DERIVATION

According to the Electron Sea Model of metallic bonding, metals consist of a lattice of positive ions surrounded by a "sea" of delocalized valence electrons.

Formula:

Not applicable.

Solution:

- Metals have low ionization energies, so their valence electrons are easily detached from individual atoms.
- These delocalized electrons are highly mobile and free to move throughout the entire metallic lattice.
- When an electrical potential is applied, these free electrons drift, facilitating metallic electrical and thermal conduction.

Why other options are incorrect:

Atoms and positive ions remain relatively fixed in their lattice positions (they only vibrate). Molecules do not exist in standard metallic lattices.

Question #73 **Key: (D)**

MDCAT 2010

Which type of force is present in gasoline?

CORE CONCEPT AND DERIVATION

Gasoline (petrol) is a mixture of various alkanes and hydrocarbons (e.g., octane, C_8H_{18}). Hydrocarbons are essentially non-polar molecules.

Formula:

Not applicable.

Solution:

- Because the electronegativity difference between Carbon and Hydrogen is negligible, hydrocarbon molecules have no permanent dipole moment.
- The only intermolecular forces capable of existing between non-polar molecules are momentary fluctuations in electron distribution.
- These temporary, induced dipoles are known as London dispersion forces.

Why other options are incorrect:

Dipole-dipole and Hydrogen bonding require permanent polarity, which gasoline lacks. Dipole-induced dipole forces require a mixture of a polar and a non-polar substance.