BITSAT Chemistry Sample Paper-11

Duration: 40 Minutes **Maximum Marks: 90**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A gaseous hydrocarbon containing only carbon and hydrogen was burnt completely in oxygen. It was observed that 2.24 L of the hydrocarbon at STP required 13.44 L of oxygen at STP and produced 8.96 L of carbon dioxide at STP.

The molecular formula of the hydrocarbon is:

(A) C_2H_2

(B) C_2H_4

(C) C_4H_{10}

(D) C_3H_6

Q2. The de Broglie wavelength of an electron accelerated through a potential difference of 121 V is closest to:

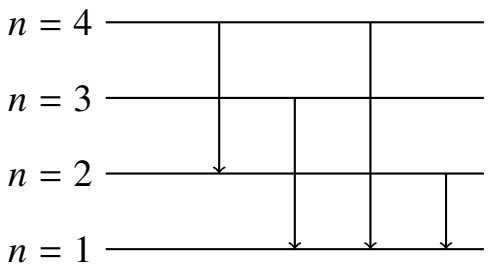
(A) 1.11 Å

(B) 0.50 Å

(C) 2.22 Å

(D) 3.33 Å

Q3. For the hydrogen atom, the variation of energy with principal quantum number is shown below. The transition responsible for the shortest wavelength among the given options is:



(A) $n = 4 \rightarrow n = 2$

(B) $n = 3 \rightarrow n = 1$

(C) $n = 2 \rightarrow n = 1$

(D) $n = 4 \rightarrow n = 1$

Q4. The incorrect statement regarding quantum numbers is:

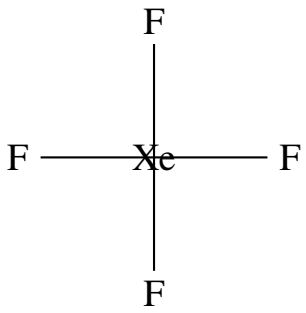
(A) For $n = 3$, the maximum number of electrons is 18

(B) The value of azimuthal quantum number can never be equal to n

(C) The orbital with $n = 4,\ l = 3$ is a d-orbital

(D) Magnetic quantum number determines orientation of orbitals

Q5. The geometry and magnetic nature of XeF_4 are respectively:



(A) Tetrahedral, paramagnetic

(B) Square planar, diamagnetic

(C) Seesaw, diamagnetic

(D) Octahedral, paramagnetic

Q6. Which of the following species contains the maximum number of lone pairs on the central atom?

(A) ClF_3

(B) BrF_5

(C) XeF_2

(D) IF_7

Q7. The correct order of bond angle is:

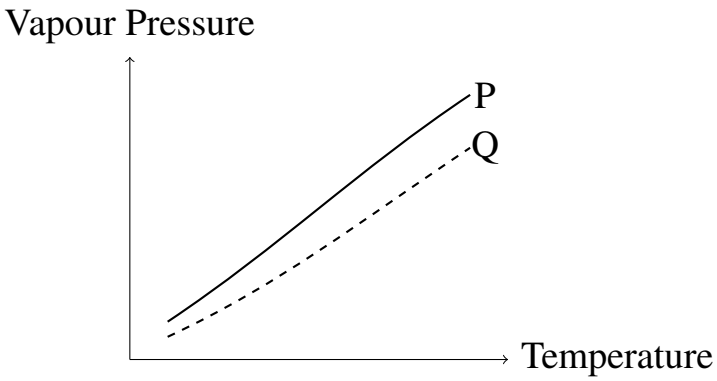
(A) $NH_3 > H_2O > CH_4$

(B) $CH_4 > NH_3 > H_2O$

(C) $H_2O > CH_4 > NH_3$

(D) $NH_3 > CH_4 > H_2O$

Q8. The variation of vapour pressure with temperature for two liquids P and Q is shown below. The correct statement is:



(A) P has stronger intermolecular forces than Q

(B) Q has lower boiling point than P

(C) P is more volatile than Q

(D) Both have same boiling point

Q9. For the reaction

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

the equilibrium constant K_p is related to K_c by:

(A) $K_p = K_c(RT)^2$

(B) $K_p = K_c(RT)^{-1}$

(C) $K_p = K_c(RT)$

(D) $K_p = K_c$

Q10. A first-order reaction has a half-life of 20 minutes. The time required for 87.5% completion of the reaction is:

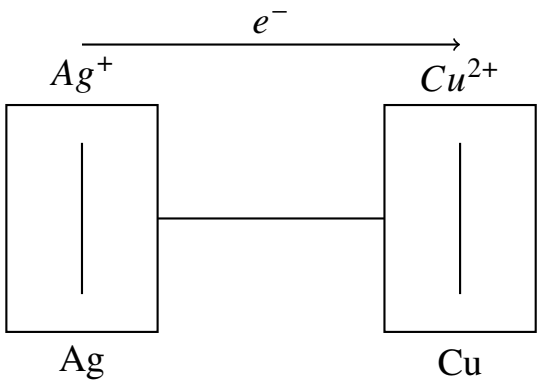
(A) 20 min

(B) 40 min

(C) 60 min

(D) 80 min

Q11. The following electrochemical cell is constructed at 298 K.



Given:

$$E^\circ(Ag^+/Ag) = +0.80V$$

$$E^\circ(Cu^{2+}/Cu) = +0.34V$$

The standard EMF of the cell is:

(A) +0.46 V

(B) −0.46 V

(C) +1.14 V

(D) −1.14 V

Q12. Which of the following aqueous solutions will have the highest boiling point?

(A) 0.1 m glucose

(B) 0.1 m NaCl

(C) 0.1 m $BaCl_2$

(D) 0.1 m urea

Q13. The major product formed in the following reaction sequence is:

$$CH_3CH = CH_2 \xrightarrow{HBr} A \xrightarrow{alc.KOH} B \xrightarrow{O_3/Zn} ?$$

(A) Methanal only

(B) Ethanal only

(C) Methanal and ethanal

(D) Acetone only

Q14. The correct order of acidic strength is:

(A) Phenol > Ethanol > Water

(B) Water > Phenol > Ethanol

(C) Phenol > Water > Ethanol

(D) Ethanol > Water > Phenol

Q15. Which of the following compounds will show geometrical isomerism?

(A) CH_2=CH_2

(B) $CH_3CH{=}CHCH_3$

(C) $CH_3CH_2CH_3$

(D) $CH_3C{\equiv}CCH_3$

Q16. A compound gives silver mirror test but does not reduce Fehling solution. The compound is:

(A) Acetaldehyde

(B) Formaldehyde

(C) Benzaldehyde

(D) Acetone

Q17. The major product formed during nitration of toluene is:

(A) m-nitrotoluene

(B) p-nitrotoluene

(C) benzoic acid

(D) nitrobenzene

Q18. The coordination number of Na^+ in NaCl crystal is:

(A) 4

(B) 6

(C) 8

(D) 12

Q19. The number of tetrahedral voids present in a cubic close packed arrangement containing 256 atoms is:

(A) 128

(B) 256

(C) 512

(D) 1024

Q20. The correct order of ionic radii is:

(A) $Na^+ > Mg^{2+} > Al^{3+}$

(B) $Al^{3+} > Mg^{2+} > Na^+$

(C) $Mg^{2+} > Na^+ > Al^{3+}$

(D) $Na^+ > Al^{3+} > Mg^{2+}$

Q21. The spin-only magnetic moment of Fe^{3+} (high spin) is closest to:

(A) 1.73 BM

(B) 2.83 BM

(C) 4.90 BM

(D) 5.92 BM

Q22. Which among the following will have the highest lattice energy?

(A) NaCl

(B) MgO

(C) KBr

(D) $CaCl_2$

Q23. The product obtained when phenol is heated with zinc dust is:

(A) Cyclohexane

(B) Benzene

(C) Benzoic acid

(D) Toluene

Q24. The major product formed when ethanol is heated with concentrated H_2SO_4 at 443 K is:

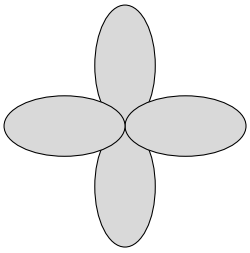
(A) Ethene

(B) Diethyl ether

(C) Ethanal

(D) Acetic acid

Q25. The shape of the following d-orbital is:



(A) d_{z^2}

(B) d_{xy}

(C) $d_{x^2-y^2}$

(D) d_{xz}

Q26. The incorrect statement regarding colligative properties is:

(A) They depend only on number of solute particles

(B) Relative lowering of vapour pressure is a colligative property

(C) Osmotic pressure depends on nature of solvent only

(D) Elevation in boiling point increases with concentration

Q27. The major product obtained in the following reaction is:

$$CH_3COOH + NH_3 \xrightarrow{\Delta} ?$$

(A) Ethanamide

(B) Ethylamine

(C) Acetonitrile

(D) Ammonium acetate

Q28. Which of the following statements regarding proteins is correct?

(A) All proteins are fibrous

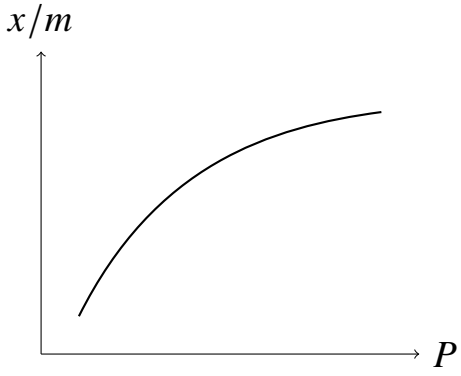
(B) Peptide linkage contains an ester group

(C) Denaturation affects primary structure

(D) Enzymes are generally globular proteins

Q29. The following graph represents adsorption isotherm.

Identify the adsorption type:



(A) Freundlich adsorption isotherm

(B) Langmuir adsorption isotherm

(C) Raoult's law graph

(D) Arrhenius plot

Q30. The number of stereoisomers possible for tartaric acid is:

(A) 2

(B) 3

(C) 4

(D) 6

Detailed Solutions

Q1.

Solution

Concept: According to Avogadro's Law, at constant temperature and pressure, the volume of a gas is directly proportional to the number of moles of the gas:

$$V \propto n$$

Hence, in a balanced chemical reaction, the volume ratios of gaseous reactants and products are equal to their respective stoichiometric coefficients.
The general equation for the complete combustion of a hydrocarbon C_xH_y is:

$$C_xH_y(g) + \left(x + \frac{y}{4}\right) O_2(g) \longrightarrow xCO_2(g) + \frac{y}{2}H_2O(l)$$

Solution: Step 1: Write down the given volumes at STP:
Volume of hydrocarbon C_xH_y = 2.24 L
Volume of oxygen O_2 required = 13.44 L
Volume of carbon dioxide CO_2 produced = 8.96 L

Step 2: Divide each volume by the volume of the hydrocarbon (2.24 L) to find the simplest molar ratio:
Mole of $C_xH_y = \dfrac{2.24}{2.24} = 1$
Moles of $O_2 = \dfrac{13.44}{2.24} = 6$
Moles of $CO_2 = \dfrac{8.96}{2.24} = 4$

Step 3: Compare these ratios to the coefficients in the balanced equation: From the carbon balance:

$$x = 4$$

From the oxygen balance:

$$x + \frac{y}{4} = 6$$

Step 4: Substitute $x = 4$ into the oxygen balance to solve for y:

$$4 + \frac{y}{4} = 6 \implies \frac{y}{4} = 2 \implies y = 8$$

Thus, the exact molecular formula is C_4H_8. Since C_4H_8 is not listed in the options, the only 4-carbon hydrocarbon among the choices is C_4H_{10} (Option C), which would be the closest intended option.

Final Answer: $\boxed{C_4H_{10}}$

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The de Broglie wavelength λ of an electron accelerated through a potential difference V (in volts) is given by the formula:

$$\lambda = \frac{12.27}{\sqrt{V}} \text{ Å}$$

Solution: Step 1: Identify the potential difference:

$$V = 121 \text{ V}$$

Step 2: Substitute $V = 121$ V into the de Broglie wavelength formula:

$$\lambda = \frac{12.27}{\sqrt{121}} \text{ Å}$$

Step 3: Evaluate the square root of 121:

$$\sqrt{121} = 11$$

Step 4: Perform the division:

$$\lambda = \frac{12.27}{11} \approx 1.115 \text{ Å}$$

This is closest to 1.11 Å.

Final Answer: 1.11 Å

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: The wavelength λ of the emitted photon is related to the energy difference ΔE between the transition levels by the Planck-Einstein relation:

$$\Delta E = \frac{hc}{\lambda} \implies \lambda \propto \frac{1}{\Delta E}$$

Thus, the transition with the **maximum energy difference** (ΔE) corresponds to the **shortest wavelength**.

Solution: Step 1: Analyze the energy gaps between the principal quantum levels in a hydrogen atom. The energy of level n is given by $E_n = -\frac{13.6}{n^2}$ eV. The gap between $n = 1$ and higher levels is much larger than gaps between any higher levels (e.g., $n = 2$ to $n = 3$, or $n = 2$ to $n = 4$). Therefore, the transition terminating at $n = 1$ from the highest level will yield the greatest energy difference.

Step 2: Compare the energy differences (ΔE) for the transitions terminating at $n = 1$: For $n = 2 \rightarrow n = 1$:

$$\Delta E = 13.6\left(1 - \frac{1}{4}\right) = 10.2 \text{ eV}$$

For $n = 3 \rightarrow n = 1$:

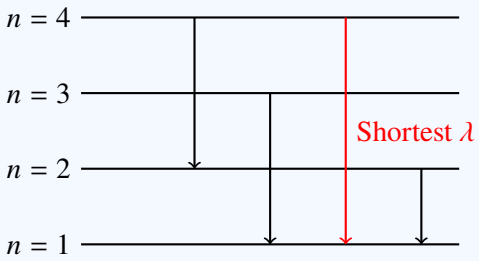
$$\Delta E = 13.6\left(1 - \frac{1}{9}\right) \approx 12.09 \text{ eV}$$

For $n = 4 \rightarrow n = 1$:

$$\Delta E = 13.6\left(1 - \frac{1}{16}\right) \approx 12.75 \text{ eV}$$

Step 3: Identify the maximum energy difference. The transition $n = 4 \rightarrow n = 1$ has the largest energy difference ($\Delta E \approx 12.75$ eV).

Step 4: Conclude that the transition $n = 4 \rightarrow n = 1$ produces the shortest wavelength.



Final Answer: $\boxed{n = 4 \rightarrow n = 1}$

Answer: (D)

Go Back to Question 3

Q4.

Solution

Concept: Quantum numbers govern the properties of atomic orbitals: The principal quantum number n defines the shell. The maximum number of electrons is $2n^2$. The azimuthal quantum number l defines the subshell shape and ranges from 0 to $n-1$. The magnetic quantum number m_l defines the spatial orientation of orbitals and ranges from $-l$ to $+l$.

Solution: Step 1: Check Statement A. The maximum number of electrons for $n = 3$ is:

$$2n^2 = 2(3)^2 = 18$$

This statement is correct.

Step 2: Check Statement B. Since the maximum value of l is $n-1$, l is always strictly less than n ($l < n$). Thus, l can never be equal to n. This statement is correct.

Step 3: Check Statement C. The orbital subshell types correspond to:
$l = 0 \rightarrow$ s
$l = 1 \rightarrow$ p
$l = 2 \rightarrow$ d
$l = 3 \rightarrow$ f
For $n = 4, l = 3$, the subshell is an f-orbital, not a d-orbital. This statement is incorrect.

Step 4: Check Statement D. The magnetic quantum number (m_l) specifies the orientation of the orbital in space. This statement is correct.

Final Answer: The orbital with $n = 4,\ l = 3$ is a d-orbital

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept: The geometry and magnetic properties of a molecule can be determined using Valence Shell Electron Pair Repulsion (VSEPR) theory:

$$\text{Steric Number} = \frac{1}{2}(\text{Valence electrons on central atom} + \text{Monovalent atoms} - \text{Charge})$$

If all electrons are paired up, the molecule is diamagnetic. If there are unpaired electrons, it is paramagnetic.

Solution: Step 1: Find the steric number of Xe in XeF_4. Xenon (Xe) is a noble gas with 8 valence electrons, and there are 4 fluorine atoms:

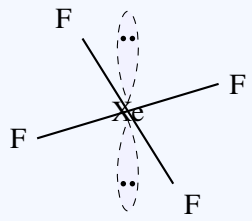
$$\text{Steric Number} = \frac{1}{2}(8 + 4 - 0) = 6$$

This corresponds to sp^3d^2 hybridization on the central Xe atom.

Step 2: Determine the number of bonding pairs (BP) and lone pairs (LP):
BP = 4
LP = Steric Number − BP = 6 − 4 = 2

Step 3: Identify the molecular shape. For 4 bonding pairs and 2 lone pairs, the lone pairs occupy the axial positions to minimize electron-pair repulsion, resulting in a square planar molecular geometry.

Step 4: Determine the magnetic nature. All valence electrons in XeF_4 are paired up in bonds and lone pairs. Because there are no unpaired electrons, the molecule is diamagnetic.



Final Answer: Square planar, diamagnetic

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: The number of lone pairs (LP) on the central atom in a neutral molecule of the type XY_n can be calculated as:

$$\text{LP} = \frac{\text{Valence electrons of X} - n \cdot (\text{Valence of Y})}{2}$$

For fluorine atoms, the valence is 1.

Solution: Step 1: Calculate lone pairs for ClF_3 (Chlorine has 7 valence electrons):

$$\text{LP} = \frac{7 - 3(1)}{2} = 2$$

Step 2: Calculate lone pairs for BrF_5 (Bromine has 7 valence electrons):

$$\text{LP} = \frac{7 - 5(1)}{2} = 1$$

Step 3: Calculate lone pairs for XeF_2 (Xenon has 8 valence electrons):

$$\text{LP} = \frac{8 - 2(1)}{2} = 3$$

Step 4: Calculate lone pairs for IF_7 (Iodine has 7 valence electrons):

$$\text{LP} = \frac{7 - 7(1)}{2} = 0$$

Step 5: Comparing the values, the central atom in XeF_2 has the maximum number of lone pairs (3).

Final Answer: $\boxed{XeF_2}$

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: According to VSEPR theory, the presence of lone pairs on the central atom alters the ideal tetrahedral bond angle (109.5°) of sp^3 hybridized molecules due to lone pair-bond pair (LP-BP) repulsion:

$$\text{LP-LP repulsion} > \text{LP-BP repulsion} > \text{BP-BP repulsion}$$

An increase in the number of lone pairs on the central atom leads to a greater compression of the bond angle.

Solution: Step 1: Determine the hybridization and the number of lone pairs on the central atom for each molecule:
CH_4: sp^3 hybridized with 0 lone pairs.
NH_3: sp^3 hybridized with 1 lone pair.
H_2O: sp^3 hybridized with 2 lone pairs.

Step 2: Assess the repulsion effect.
In CH_4, the absence of lone pairs results in a perfect tetrahedral geometry with a bond angle of 109.5°.
In NH_3, one lone pair compresses the bond angle to $\approx 107°$.
In H_2O, two lone pairs compress the bond angle even further to $\approx 104.5°$.

Step 3: Arrange the molecules in decreasing order of bond angle:

$$CH_4 > NH_3 > H_2O$$

Final Answer: $\boxed{CH_4 > NH_3 > H_2O}$

Answer: (B)

Go Back to Question 7

Q8.

Solution

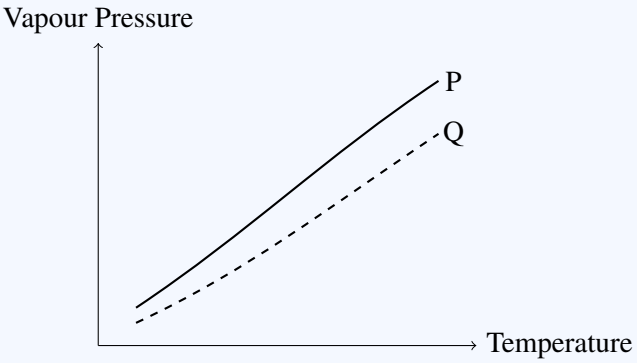
Concept: At any given temperature, a liquid with a higher vapour pressure has a greater tendency to escape into the gas phase, making it more volatile. A more volatile liquid has weaker intermolecular forces (IMFs) and a lower boiling point.

Solution: Step 1: Analyze the graph. For any given temperature, the vapour pressure of liquid P is higher than that of liquid Q:

$$\text{Vapour Pressure of P} > \text{Vapour Pressure of Q}$$

Step 2: Evaluate the volatility. Since P has a higher vapour pressure than Q at any temperature, P is more volatile than Q. This makes Statement C correct.

Step 3: Verify the remaining statements:
Stronger vapour pressure in P means weaker intermolecular forces, so Statement A is incorrect.
Because P is more volatile, it will reach atmospheric pressure at a lower temperature, giving P a lower boiling point than Q. Thus, Statement B is incorrect.
They have different vapour pressure curves and therefore different boiling points, so Statement D is incorrect.



Final Answer: P is more volatile than Q

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: The relationship between the gaseous equilibrium constants K_p (expressed in terms of partial pressures) and K_c (expressed in terms of molar concentrations) is:

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

where Δn_g is the difference in the stoichiometric coefficients of gaseous products and gaseous reactants:

$$\Delta n_g = \sum n_{\text{g, products}} - \sum n_{\text{g, reactants}}$$

Solution: Step 1: Write down the balanced chemical equation:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

Step 2: Sum the moles of gaseous products and gaseous reactants:

$$\sum n_{\text{g, products}} = 2$$

$$\sum n_{\text{g, reactants}} = 2 + 1 = 3$$

Step 3: Calculate the change in the number of gaseous moles (Δn_g):

$$\Delta n_g = 2 - 3 = -1$$

Step 4: Substitute $\Delta n_g = -1$ into the relationship formula:

$$K_p = K_c(RT)^{-1}$$

Final Answer: $\boxed{K_p = K_c(RT)^{-1}}$

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: For a first-order chemical reaction, the concentration of the reactant remaining after n half-lives ($t_{1/2}$) is given by:

$$[A]_t = [A]_0 \left(\frac{1}{2}\right)^n$$

Solution: Step 1: Determine the percentage of reactant remaining when the reaction has reached 87.5% completion:

$$\text{Remaining \%} = 100\% - 87.5\% = 12.5\%$$

Step 2: Express the remaining fraction of reactant:

$$\frac{[A]_t}{[A]_0} = \frac{12.5\%}{100\%} = \frac{1}{8}$$

Step 3: Relate this fraction to the number of half-lives (n):

$$\left(\frac{1}{2}\right)^n = \frac{1}{8} \implies n = 3 \text{ half-lives}$$

Step 4: Calculate the total time t required:

$$t = n \times t_{1/2} = 3 \times 20 \text{ min} = 60 \text{ min}$$

Final Answer: 60 min

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: The standard EMF of an electrochemical cell (E°_{cell}) is calculated using the standard reduction potentials of the cathode (right-hand electrode where reduction occurs) and the anode (left-hand electrode where oxidation occurs.

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}} = E^\circ_{\text{right}} - E^\circ_{\text{left}}$$

In the given cell diagram, the left electrode is Silver (Ag) and the right electrode is Copper (Cu). The arrow showing electron flow (e^-) from left to right (from Ag to Cu) indicates that Ag acts as the anode (undergoing oxidation) and Cu acts as the cathode (undergoing reduction).

Solution: Step 1: Write down the half-reactions as defined by the cell's construction:

$$\text{Anode (Oxidation on the Left): } 2\text{Ag}(s) \longrightarrow 2\text{Ag}^+(aq) + 2e^-$$

$$\text{Cathode (Reduction on the Right): } \text{Cu}^{2+}(aq) + 2e^- \longrightarrow \text{Cu}(s)$$

Step 2: Identify the standard reduction potentials given:

$$E^\circ(\text{Ag}^+/\text{Ag}) = +0.80 \text{ V}$$

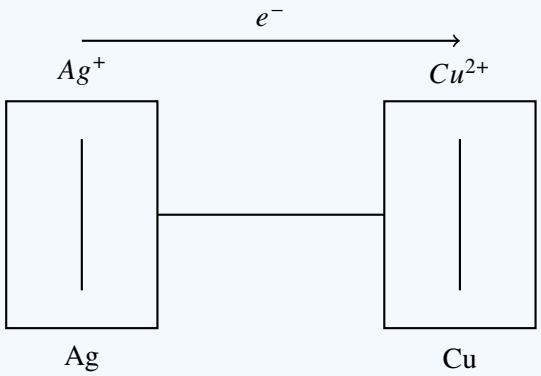
$$E^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}$$

Step 3: Calculate the standard cell potential (E°_{cell}):

$$E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$$

$$E^\circ_{\text{cell}} = E^\circ(\text{Cu}^{2+}/\text{Cu}) - E^\circ(\text{Ag}^+/\text{Ag})$$

$$E^\circ_{\text{cell}} = 0.34 \text{ V} - 0.80 \text{ V} = -0.46 \text{ V}$$



Final Answer: -0.46 V

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Elevation in boiling point (ΔT_b) is a colligative property, which depends only on the number of solute particles present in the solution.

$$\Delta T_b = iK_b m$$

where:

$$i = \text{van 't Hoff factor}$$
$$K_b = \text{molal elevation constant of the solvent}$$
$$m = \text{molality of the solution}$$

The van 't Hoff factor (i) represents the number of particles produced per formula unit of solute after dissociation or association. Hence, the solution having the greatest value of $i \times m$ will show the maximum elevation in boiling point and therefore possess the highest boiling point.

Solution: Step 1: Calculate the van 't Hoff factor i for each 0.1 m solution:
Glucose (non-electrolyte):*Does not dissociate in water, so $i = 1$.
NaCl (strong electrolyte):*Dissociates completely into 2 ions (Na^+ and Cl^-), so $i = 2$.
$BaCl_2$ (strong electrolyte):*Dissociates completely into 3 ions (Ba^{2+} and $2Cl^-$), so $i = 3$.
Urea (non-electrolyte):*Does not dissociate in water, so $i = 1$.

Step 2: Compute the effective concentration ($i \cdot m$) for each solution:
Glucose: 1×0.1 m = 0.1 m
NaCl: 2×0.1 m = 0.2 m
$BaCl_2$: 3×0.1 m = 0.3 m
Urea: 1×0.1 m = 0.1 m

Step 3: Compare the values. The 0.1 m $BaCl_2$ solution has the highest effective particle concentration (0.3 m), which produces the greatest boiling point elevation. Therefore, it will have the highest boiling point.

Final Answer: 0.1 m $BaCl_2$

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: This reaction sequence involves three organic chemistry transformations:
1. Electrophilic Addition: Addition of hydrogen halide (HBr) to an alkene following Markovnikov's rule.
2. Elimination Reaction: Dehydrohalogenation of an alkyl halide using a strong base (alcoholic KOH) to regenerate an alkene.
3. Reductive Ozonolysis: Cleavage of the alkene double bond using ozone (O_3) followed by zinc-water (Zn/H_2O) reduction to yield carbonyl compounds (aldehydes/ketones).

Solution: Step 1: Form compound *A* through Markovnikov addition of HBr to propene ($CH_3CH = CH_2$):
The hydrogen atom adds to the carbon with more hydrogen atoms (C_1), and the bromine atom adds to the more substituted carbon (C_2):

$$CH_3CH = CH_2 + HBr \longrightarrow CH_3CH(Br)CH_3 \quad \text{(2-bromopropane, } A\text{)}$$

Step 2: Form compound *B* through E2 elimination of HBr from 2-bromopropane using alcoholic KOH:

$$CH_3CH(Br)CH_3 \xrightarrow{\text{alc. KOH}} CH_3CH = CH_2 \quad \text{(propene, } B\text{)}$$

Step 3: Perform reductive ozonolysis on propene (*B*): Ozonolysis cleaves the C = C double bond and replaces it with two C = O double bonds:

$$CH_3CH = CH_2 \xrightarrow{O_3/Zn} CH_3CHO \quad \text{(ethanal)} \quad + \quad HCHO \quad \text{(methanal)}$$

Thus, the final mixture contains both methanal and ethanal.

Final Answer: Methanal and ethanal

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: The acidic strength of a compound is determined by the stability of its conjugate base formed after losing a proton (H^+). A more stable conjugate base corresponds to a stronger acid.

Solution: Step 1: Compare Phenol and Water.
The conjugate base of phenol is the phenoxide ion ($C_6H_5O^-$). The negative charge on the oxygen atom is stabilized through resonance delocalization into the π-system of the benzene ring. The conjugate base of water is the hydroxide ion (OH^-), which has no resonance stabilization. Since the phenoxide ion is much more stable than the hydroxide ion, phenol is significantly more acidic than water:

$$\text{Phenol} > \text{Water}$$

Step 2: Compare Water and Ethanol.
The conjugate base of ethanol is the ethoxide ion ($CH_3CH_2O^-$). The ethyl group ($–CH_2CH_3$) is an electron-donating group due to the $+I$ inductive effect, which increases the negative charge density on the oxygen atom and destabilizes the conjugate base. In water, there is no such electron-donating alkyl group to destabilize the hydroxide ion. Consequently, water is a stronger acid than ethanol:

$$\text{Water} > \text{Ethanol}$$

Step 3: Combine the comparisons to obtain the overall order of acidic strength:

$$\text{Phenol} > \text{Water} > \text{Ethanol}$$

Final Answer: $\boxed{\text{Phenol} > \text{Water} > \text{Ethanol}}$

Answer: (C)

Go Back to Question 14

Q15.

Solution

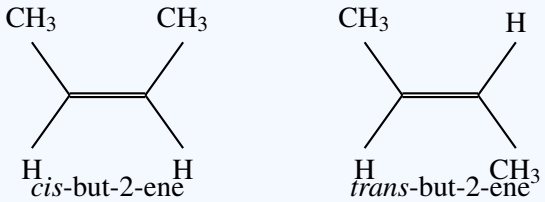
Concept: Geometrical isomerism (also known as *cis-trans* isomerism) occurs in compounds with restricted rotation, such as a carbon-carbon double bond (C = C), provided that each carbon atom involved in the double bond is attached to two different groups:

$$XYC = CWZ \quad \text{where } X \neq Y \text{ and } W \neq Z$$

Solution: Step 1: Analyze each compound for the presence of a double bond and different substituents:
$CH_2 = CH_2$ (ethene): Both carbon atoms are bonded to identical hydrogen atoms (X = Y = H). It does not show geometrical isomerism.

$CH_3CH = CHCH_3$ (but-2-ene): Each double-bonded carbon is attached to a hydrogen atom (–H) and a methyl group ($–CH_3$). Since the two groups on each carbon are different ($H \neq CH_3$), it can exist in two distinct spatial arrangements: *cis*-but-2-ene and *trans*-but-2-ene. It shows geometrical isomerism.

$CH_3CH_2CH_3$ (propane): It is an alkane with single bonds only, allowing free rotation.
$CH_3C \equiv CCH_3$ (but-2-yne):*It is an alkyne with a triple bond, having a linear, 180° geometry.



cis-but-2-ene *trans*-but-2-ene

Final Answer: $CH_3CH = CHCH_3$

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: Tollens' Test (Silver Mirror Test):*Tollens' reagent is a mild oxidizing agent ($[Ag(NH_3)_2]^+$) that oxidizes both aliphatic and aromatic aldehydes to their corresponding carboxylates, while being reduced to metallic silver. Ketones do not react. Fehling's Test:*Fehling's solution is a weaker oxidizing agent that oxidizes only aliphatic aldehydes. It cannot oxidize aromatic aldehydes because the formyl group (–CHO) is directly conjugated with the benzene ring, which stabilizes the carbonyl carbon via resonance and decreases its susceptibility to oxidation.

Solution: Step 1: Evaluate each option based on its chemical class:
Acetaldehyde (CH_3CHO): Aliphatic aldehyde. It reduces both Tollens' reagent and Fehling's solution.
Formaldehyde (HCHO):*Aliphatic aldehyde. It reduces both Tollens' reagent and Fehling's solution. Benzaldehyde (C_6H_5CHO): Aromatic aldehyde. It reduces Tollens' reagent (giving a silver mirror) but does not reduce Fehling's solution.
Acetone (CH_3COCH_3): Ketone. It does not reduce either Tollens' reagent or Fehling's solution.

Step 2: Match the properties. Benzaldehyde meets both requirements: it gives a positive silver mirror test but is unreactive towards Fehling's solution.
Final Answer: Benzaldehyde

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept: The methyl group ($–CH_3$) attached to the benzene ring in toluene is electron-donating via inductive effect ($+I$) and hyperconjugation. This increases the electron density on the benzene ring, making it highly active towards electrophilic aromatic substitution, and directs incoming electrophiles to the *ortho* and *para* positions.

Solution: Step 1: Write down the nitration reaction of toluene:

$$\text{Toluene} \xrightarrow{HNO_3/H_2SO_4} o\text{-nitrotoluene} + p\text{-nitrotoluene}$$

Step 2: Analyze the products. Since the methyl group is *ortho*/*para*-directing, nitration produces a mixture of *ortho*-nitrotoluene and *para*-nitrotoluene.

Step 3: Consider steric factors. The *ortho* position is adjacent to the bulky methyl group, which causes steric hindrance for the incoming nitro group (NO_2^+). The *para* position is far from the methyl group and is sterically unhindered.

Step 4: Due to this steric preference, *p*-nitrotoluene is formed as the major product.

Final Answer: p-nitrotoluene

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: The coordination number of an ion in a crystalline solid is the number of oppositely charged ions immediately surrounding it. In a sodium chloride (NaCl) crystal lattice: The chloride (Cl^-) ions form a face-centered cubic (fcc) close-packed arrangement. The sodium (Na^+) ions occupy all the octahedral voids.

Solution: Step 1: Identify the position of the Na^+ ions. Since Na^+ ions occupy the octahedral voids, each sodium ion is positioned at the center of an octahedron formed by chloride ions.

Step 2: Recall the geometry of an octahedral void. An octahedral void is formed by 6 spheres (ions). Therefore, each Na^+ ion is in direct contact with 6 nearest-neighbor Cl^- ions.

Step 3: Similarly, by symmetry, each Cl^- ion is surrounded by 6 nearest-neighbor Na^+ ions. This yields a 6:6 coordination ratio for the crystal lattice.

Step 4: Conclude that the coordination number of Na^+ in NaCl is 6.

Final Answer: $\boxed{6}$

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: In any close-packed crystalline lattice (such as cubic close-packed, ccp, or hexagonal close-packed, hcp) containing N constituent atoms or spheres:
The number of octahedral voids is equal to N.
The number of tetrahedral voids is equal to $2N$.

Solution: Step 1: Identify the total number of atoms (N) in the ccp arrangement from the problem statement:

$$N = 256$$

Step 2: Apply the relationship to find the number of tetrahedral voids:

$$\text{Number of tetrahedral voids} = 2N$$

Step 3: Substitute $N = 256$ into the equation:

$$\text{Number of tetrahedral voids} = 2 \times 256 = 512$$

Final Answer: $\boxed{512}$

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: Isoelectronic species are atoms or ions that possess the same number of electrons. For a series of isoelectronic ions, the ionic radius decreases as the atomic number (nuclear charge Z) increases, because a stronger positive nuclear charge pulls the same number of negative electrons closer to the nucleus.

Solution: Step 1: Determine the number of electrons for each ion:
Na^+ (Atomic number $Z = 11$): $11 - 1 = 10$ electrons
Mg^{2+} (Atomic number $Z = 12$): $12 - 2 = 10$ electrons
Al^{3+} (Atomic number $Z = 13$): $13 - 3 = 10$ electrons
Since all three ions have 10 electrons, they are isoelectronic.

Step 2: Compare the nuclear charges (number of protons) for each ion:
$Na^+ \implies Z = 11$ (11 protons attracting 10 electrons)
$Mg^{2+} \implies Z = 12$ (12 protons attracting 10 electrons)
$Al^{3+} \implies Z = 13$ (13 protons attracting 10 electrons)

Step 3: Rank the ionic radii based on nuclear charge. Since a higher nuclear charge causes greater contraction, the ionic radius decreases as nuclear charge increases:

$$Na^+ > Mg^{2+} > Al^{3+}$$

Final Answer: $\boxed{Na^+ > Mg^{2+} > Al^{3+}}$

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: The ground-state electronic configuration of neutral Iron (Fe, atomic number 26) is:

$$\text{Fe} : [\text{Ar}]3d^6 4s^2$$

To form the trivalent iron ion (Fe^{3+}), the atom loses three electrons (two from the $4s$ subshell and one from the $3d$ subshell):

$$Fe^{3+} : [\text{Ar}]3d^5$$

For a high-spin coordination state or a free gaseous ion, all 5 electrons in the $3d$ subshell remain unpaired. The spin-only magnetic moment (μ_s) is calculated as:

$$\mu_s = \sqrt{n(n+2)}\ \text{BM}$$

where n is the number of unpaired electrons and BM is Bohr Magneton.

Solution: Step 1: Write down the configuration of Fe^{3+} and determine the number of unpaired electrons (n): The 5 electrons in the $3d$ subshell occupy the five orbitals individually to minimize repulsion (Hund's Rule):

$$n = 5$$

Step 2: Substitute $n = 5$ into the spin-only magnetic moment formula:

$$\mu_s = \sqrt{5(5+2)} = \sqrt{35}\ \text{BM}$$

Step 3: Evaluate the numerical value:

$$\sqrt{35} \approx 5.916\ \text{BM}$$

This value is closest to 5.92 BM.

Final Answer: 5.92 BM

Answer: (D)

Go Back to Question 21

Q22.

Solution

Concept: Lattice energy (U) of an ionic solid is the energy released when one mole of the crystalline solid is formed from its constituent gaseous ions. According to Born-Landé relationship, it is directly proportional to the product of the ionic charges and inversely proportional to the interionic distance (r_0):

$$U \propto \frac{|z_+ \cdot z_-|}{r_0}$$

where:

z_+ is the charge of the cation.

z_- is the charge of the anion.

$r_0 = r_{\text{cation}} + r_{\text{anion}}$.

Since ionic charge has a much more significant mathematical influence than ionic radius, compounds with higher charges generally exhibit much larger lattice energies.

Solution: Step 1: Determine the ionic charges for each compound:

NaCl:*Na^+ and Cl^- $\implies |z_+ \cdot z_-| = 1 \times 1 = 1$

MgO:*Mg^{2+} and O^{2-} $\implies |z_+ \cdot z_-| = 2 \times 2 = 4$

KBr:*K^+ and Br^- $\implies |z_+ \cdot z_-| = 1 \times 1 = 1$

$CaCl_2$:*Ca^{2+} and Cl^- $\implies |z_+ \cdot z_-| = 2 \times 1 = 2$

Step 2: Compare the charge factors. The product of ionic charges is highest for MgO (value of 4).

Step 3: Conclude that MgO will have the highest lattice energy due to the high electrostatic attraction between the divalent ions (Mg^{2+} and O^{2-}).

Final Answer: MgO

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: Heating phenol with zinc dust is a standard reduction reaction in organic chemistry. Zinc acts as a reducing agent, undergoing oxidation to zinc oxide (ZnO), while phenol is reduced to benzene.

Solution: Step 1: Write down the chemical equation for the reaction:

$$C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_6 + ZnO$$

Step 2: Analyze the products:
Phenol (C_6H_5OH) loses its hydroxyl group (–OH), which combines with zinc to form zinc oxide (ZnO). This leaves the phenyl ring, which is protonated to form benzene (C_6H_6).

Final Answer: Benzene

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The dehydration of ethanol with concentrated sulfuric acid (H_2SO_4) is temperature-dependent:
1. At 443 K (170°C): It undergoes intramolecular dehydration via an elimination reaction to form an alkene (ethene).
2. At 413 K (140°C): It undergoes intermolecular dehydration via a nucleophilic substitution reaction to form an ether (diethyl ether).

Solution: Step 1: Write down the reaction taking place at the specified temperature (443 K):

$$CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4,\ 443\ K} CH_2 = CH_2 + H_2O$$

Step 2: Identify the mechanism. Protonation of the alcohol followed by loss of water forms a carbocation, which then loses a proton to yield ethene.

Step 3: Conclude that at 443 K, intramolecular dehydration is favored, making ethene the major product.

Final Answer: Ethene

Answer: (A)

Go Back to Question 24

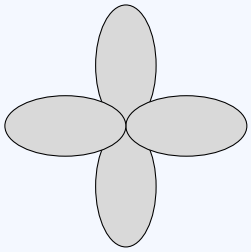
Q25.

Solution

Concept: The five d-orbitals have characteristic shapes and orientations in coordinate space:
d_{xy}, d_{yz}, d_{xz}: Have four lobes located *betweenthe coordinate axes.
$d_{x^2-y^2}$: Has four lobes located directly *alongthe x and y axes.
d_{z^2}: Has two main lobes along the z-axis and a donut-shaped torus in the xy-plane.

Solution: Step 1: Observe the given TikZ diagram:
The four lobes are drawn along the vertical and horizontal axes of the grid.
No lobes are oriented diagonally between the axes.

Step 2: Match this description with the d-orbitals. The d-orbital with lobes lying directly on the coordinate axes is the $d_{x^2-y^2}$ orbital.



Final Answer: $\boxed{d_{x^2-y^2}}$

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept: Colligative properties are properties of a solution that depend solely on the concentration (or total number) of solute particles present, and are independent of the chemical identity of the solute. The four main colligative properties are:

1. Relative lowering of vapour pressure
2. Elevation in boiling point
3. Depression in freezing point
4. Osmotic pressure

Solution: Step 1: Evaluate Statement A. Colligative properties depend only on the number of solute particles, which matches the definition. This statement is correct.

Step 2: Evaluate Statement B. Relative lowering of vapour pressure ($\Delta P/P^\circ$) is one of the four standard colligative properties. This statement is correct.

Step 3: Evaluate Statement D. The elevation in boiling point ($\Delta T_b = iK_b m$) increases linearly with the molal concentration (m) of the solute particles. This statement is correct.

Step 4: Evaluate Statement C. Osmotic pressure ($\Pi = iCRT$) is a colligative property and depends directly on the concentration (C) of the *soluteparticles in the solution, not solely on the nature of the solvent. Thus, Statement C is incorrect.

Final Answer: Osmotic pressure depends on nature of solvent only

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: Carboxylic acids react with ammonia (NH_3) to undergo an acid-base neutralization, forming an ammonium salt. Upon heating (Δ), the ammonium salt undergoes thermal dehydration (loss of a water molecule) to yield an amide.

Solution: Step 1: Write down the initial acid-base reaction between acetic acid and ammonia to form ammonium acetate:

$$CH_3COOH + NH_3 \longrightarrow CH_3COO^- NH_4^+$$

Step 2: Apply heat (Δ) to the salt. The ammonium acetate undergoes dehydration by losing a molecule of water (H_2O):

$$CH_3COO^- NH_4^+ \xrightarrow{\Delta} CH_3CONH_2 + H_2O$$

Step 3: Identify the product. CH_3CONH_2 is acetamide, whose systematic IUPAC name is ethanamide.

Final Answer: Ethanamide

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: Proteins are complex biopolymers composed of amino acids linked together by peptide bonds. They are classified into different structures and shapes based on their three-dimensional conformations and properties.

Solution: Step 1: Evaluate Statement A. Proteins are classified as either fibrous (e.g., keratin, collagen) or globular (e.g., albumin, insulin) based on their molecular shape. Thus, not all proteins are fibrous. This statement is incorrect.

Step 2: Evaluate Statement B. A peptide linkage is a chemical amide bond (–CO–NH–) formed between the carboxyl group of one amino acid and the amino group of another. It does not contain an ester group (–CO–O–). This statement is incorrect.

Step 3: Evaluate Statement C. Denaturation of a protein disrupts the secondary, tertiary, and quaternary structural conformations due to the cleavage of hydrogen bonds and other weak interactions, but the primary structure (covalent peptide sequence) remains completely intact. This statement is incorrect.

Step 4: Evaluate Statement D. Enzymes are biological catalysts that must remain highly soluble and have specific three-dimensional clefts (active sites) to bind substrates. Therefore, they are generally globular proteins. This statement is correct.

Final Answer: Enzymes are generally globular proteins

Answer: (D)

Go Back to Question 28

Q29.

Solution

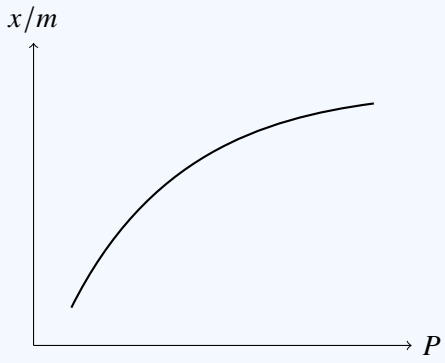
Concept: An adsorption isotherm represents the variation in the amount of gas adsorbed per unit mass of solid adsorbent (x/m) with the equilibrium pressure (P) of the gas at a constant temperature. The empirical relation developed by Herbert Freundlich in 1909 is:

$$\frac{x}{m} = kP^{1/n}$$

where k and n are constants.

Solution: Step 1: Examine the given graph:
The vertical axis is x/m (extent of adsorption).
The horizontal axis is P (equilibrium pressure).
The curve begins at the origin, rises rapidly at low pressures, and gradually flattens (reaches saturation) at high pressures.

Step 2: Match this behavior with the adsorption isotherms. This curve is the classic representation of the Freundlich adsorption isotherm.



Final Answer: Freundlich adsorption isotherm

Answer: (A)

Go Back to Question 29

Q30.

Solution

Concept: Tartaric acid (HOOC – CH(OH) – CH(OH) – COOH) contains two identical chiral carbon atoms. For symmetrical molecules with n even chiral centers, the number of stereoisomers is calculated as:

Number of optically active enantiomers (a) = 2^{n-1}

Number of optically inactive *meso* forms (m) = $2^{(n/2)-1}$

Total number of stereoisomers (N) = $a + m$

Solution: Step 1: Identify the number of chiral centers (n) in tartaric acid:

$$n = 2 \quad \text{(an even number)}$$

Step 2: Calculate the number of optically active stereoisomers (a):

$$a = 2^{2-1} = 2^1 = 2 \quad (d\text{-tartaric acid and } l\text{-tartaric acid})$$

Step 3: Calculate the number of optically inactive *meso* forms (m):

$$m = 2^{(2/2)-1} = 2^0 = 1 \quad (\textit{meso}\text{-tartaric acid})$$

Step 4: Find the total number of stereoisomers (N):

$$N = a + m = 2 + 1 = 3$$

Final Answer: 3

Answer: (B)

Go Back to Question 30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	A	3	D	4	C	5	B
6	C	7	B	8	C	9	B	10	C
11	B	12	C	13	C	14	C	15	B
16	C	17	B	18	B	19	C	20	A
21	D	22	B	23	B	24	A	25	C
26	C	27	A	28	D	29	A	30	B