BITSAT Chemistry Sample Paper-12

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 mixture contains methane and ethene in the molar ratio 2:1. If 9 g of the mixture is completely burnt in excess oxygen, the mass of CO_2 produced is:

(A) 13.2 g

(B) 17.6 g

(C) 22.0 g

(D) 26.4 g

Q2. The uncertainty in velocity of an electron is 5.8×10^5 m s^{-1}. The minimum uncertainty in its position is closest to:

$$(h = 6.626 \times 10^{-34} \text{ Js},\ m_e = 9.1 \times 10^{-31} \text{ kg})$$

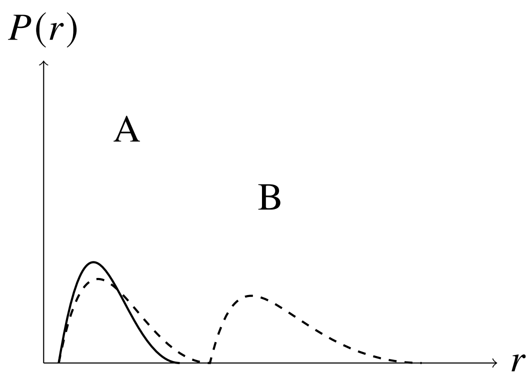
(A) 1.0×10^{-10} m

(B) 5.0×10^{-11} m

(C) 2.0×10^{-9} m

(D) 1.0×10^{-8} m

Q3. The following graph represents radial probability distribution curves for different orbitals of hydrogen atom. Identify the orbital having two radial nodes.



(A) 1s

(B) 2p

(C) 3s

(D) 2s

Q4. Among the following species, the one having the highest bond order is:

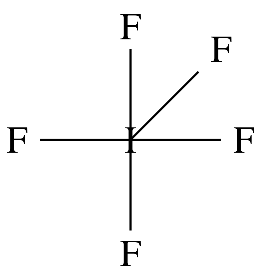
(A) O_2

(B) O_2^-

(C) O_2^+

(D) O_2^{2-}

Q5. The shape of IF_5 molecule according to VSEPR theory is:



(A) Square planar

(B) Trigonal bipyramidal

(C) Square pyramidal

(D) Octahedral

Q6. Which of the following compounds exhibits hydrogen bonding in gaseous state?

(A) HCl

(B) HF

(C) HBr

(D) HI

Q7. For the reaction

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

the equilibrium shifts in the forward direction on:

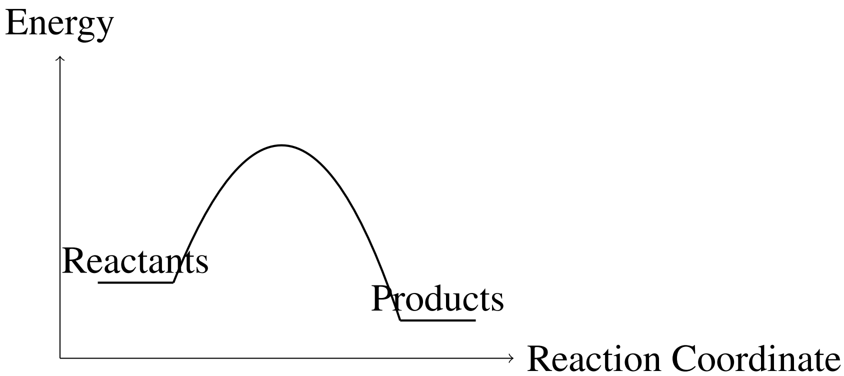
(A) increasing temperature only

(B) decreasing pressure only

(C) increasing pressure only

(D) adding catalyst only

Q8. The enthalpy diagram for a reaction is shown below. The reaction is:



(A) Endothermic with low activation energy

(B) Exothermic with high activation energy

(C) Endothermic with high activation energy

(D) Thermoneutral

Q9. The pH of a 10^{-8} M HCl solution is:

(A) 8

(B) 7

(C) slightly less than 7

(D) slightly greater than 7

Q10. For a reaction:

$$2A + B \rightarrow Products$$

the rate law is:

$$\text{Rate} = k[A]^2[B]$$

The overall order and units of k respectively are:

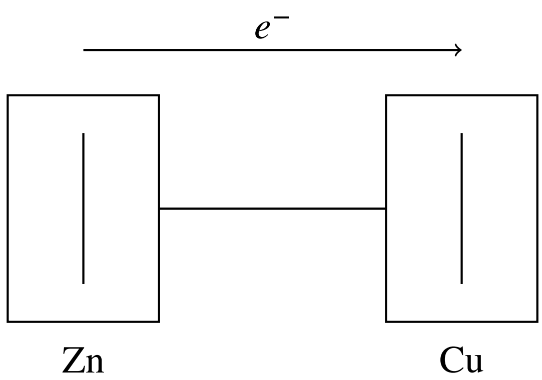
(A) 2 ; L mol^{-1} s^{-1}

(B) 3 ; L^2 mol^{-2} s^{-1}

(C) 1 ; s^{-1}

(D) 3 ; mol L^{-1} s^{-1}

Q11. The galvanic cell represented below has:



In this cell:

(A) Cu acts as anode

(B) Zn undergoes reduction

(C) electrons flow from Zn to Cu

(D) oxidation occurs at Cu electrode

Q12. Which of the following compounds shows maximum van't Hoff factor in aqueous solution?

(A) NaCl

(B) K_2SO_4

(C) Glucose

(D) Urea

Q13. The major product obtained when propene reacts with cold alkaline $KMnO_4$ is:

(A) Propanal

(B) Propanoic acid

(C) Propane-1,2-diol

(D) Acetone

Q14. Which of the following alcohols undergoes dehydration most readily?

(A) Ethanol

(B) Propan-1-ol

(C) Propan-2-ol

(D) tert-Butyl alcohol

Q15. Which of the following compounds will not undergo Friedel-Crafts alkylation?

(A) Benzene

(B) Chlorobenzene

(C) Nitrobenzene

(D) Toluene

Q16. The reagent used to distinguish between ethanal and propanone is:

(A) Tollen's reagent

(B) Fehling solution

(C) Schiff reagent

(D) All of these

Q17. The major product formed in the following reaction is:

$$C_6H_5NH_2 + Br_2(aq) \rightarrow ?$$

(A) Bromobenzene

(B) m-Bromoaniline

(C) 2,4,6-tribromoaniline

(D) p-Bromoaniline

Q18. The packing efficiency of body-centred cubic crystal is approximately:

(A) 52%

(B) 68%

(C) 74%

(D) 86%

Q19. Which crystal defect decreases density of a crystal?

(A) Frenkel defect

(B) Schottky defect

(C) Interstitial defect

(D) Metal excess defect

Q20. Among the following ions, the one having maximum hydration enthalpy is:

(A) Li^+

(B) Na^+

(C) K^+

(D) Rb^+

Q21. The complex ion responsible for the deep blue colour obtained when excess NH_3 is added to $CuSO_4$ solution is:

$Cu(NH_3)_2\ ^{2+}$

$Cu(NH_3)_4\ ^{2+}$

$Cu(NH_3)_6\ ^{2+}$

$Cu(NH_3)\ ^{2+}$

Q22. Which among the following has the highest first ionization enthalpy?

(A) B

(B) Be

(C) C

(D) N

Q23. Phenol on treatment with chloroform and NaOH gives:

(A) Salicylic acid

(B) Benzaldehyde

(C) Salicylaldehyde

(D) Anisole

Q24. The product formed when acetaldehyde reacts with HCN is:

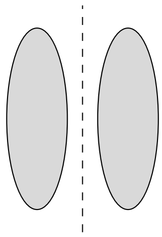
(A) Cyanohydrin

(B) Acetal

(C) Aldol

(D) Oxime

Q25. The following diagram represents:



(A) σ overlap of p-orbitals

(B) π overlap of p-orbitals

(C) hybrid orbital overlap

(D) s-p overlap

Q26. Which of the following solutions will show positive deviation from Raoult's law?

(A) Acetone + chloroform

(B) Ethanol + water

(C) Benzene + toluene

(D) Ethanol + acetone

Q27. The monomer used in the preparation of teflon is:

(A) Vinyl chloride

(B) Styrene

(C) Tetrafluoroethene

(D) Ethene

Q28. Which among the following carbohydrates is non-reducing?

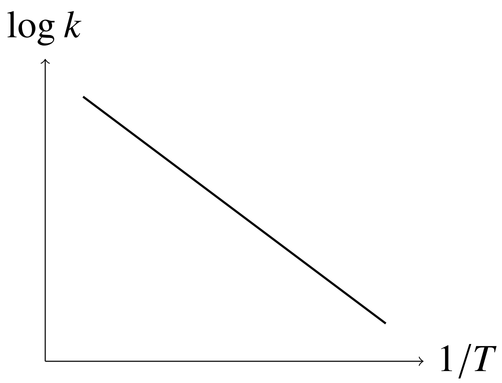
(A) Glucose

(B) Maltose

(C) Lactose

(D) Sucrose

Q29. The following graph best represents:



(A) Boyle's law

(B) Arrhenius equation

(C) Freundlich adsorption

(D) Nernst equation

Q30. Which of the following statements regarding chemisorption is correct?

(A) It is reversible

(B) It has low enthalpy of adsorption

(C) It forms a monolayer

(D) It decreases with increase in temperature at all temperatures

Detailed Solutions

Q1.

Solution

Concept: For a gaseous mixture of methane (CH_4) and ethene (C_2H_4) completely burnt in oxygen, we use the stoichiometry of the individual combustion reactions to find the total mass of carbon dioxide (CO_2) produced:

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$$

$$C_2H_4(g) + 3O_2(g) \longrightarrow 2CO_2(g) + 2H_2O(l)$$

Solution: Step 1: Set up the moles of each gas in the mixture. Since the molar ratio is 2 : 1, let:

$$\text{Moles of } CH_4 = 2x$$

$$\text{Moles of } C_2H_4 = x$$

Step 2: Express the total mass of the 9 g mixture using the molar masses of methane (16 g/mol) and ethene (28 g/mol):

$$\text{Total Mass} = (2x \times 16) + (x \times 28) = 32x + 28x = 60x$$

$$60x = 9 \implies x = \frac{9}{60} = 0.15 \text{ mol}$$

Step 3: Calculate the number of moles of each gas in the mixture:

$$\text{Moles of } CH_4 = 2 \times 0.15 = 0.30 \text{ mol}$$

$$\text{Moles of } C_2H_4 = 0.15 \text{ mol}$$

Step 4: Determine the total moles of CO_2 produced: 0.30 mol of CH_4 produces 0.30 mol of CO_2. 0.15 mol of C_2H_4 produces $2 \times 0.15 = 0.30$ mol of CO_2.

$$\text{Total moles of } CO_2 = 0.30 + 0.30 = 0.60 \text{ mol}$$

Step 5: Calculate the mass of the produced CO_2 (Molar mass of CO_2 = 44 g/mol):

$$\text{Mass of } CO_2 = 0.60 \text{ mol} \times 44 \text{ g/mol} = 26.4 \text{ g}$$

Final Answer: 26.4 g

Answer: (D)

Go Back to Question 1

Q2.

Solution

Concept: According to Heisenberg's Uncertainty Principle, the product of the uncertainty in position (Δx) and the uncertainty in momentum ($\Delta p = m\Delta v$) of a particle is given by:

$$\Delta x \cdot \Delta v \geq \frac{h}{4\pi m}$$

Solution: Step 1: Write down the given values: Planck's constant (h) = 6.626×10^{-34} J s Mass of an electron (m_e) = 9.1×10^{-31} kg Uncertainty in velocity (Δv) = 5.8×10^{5} m s^{-1}

Step 2: Rearrange the formula to solve for the minimum uncertainty in position (Δx):

$$\Delta x \geq \frac{h}{4\pi m_e \Delta v}$$

Step 3: Substitute the given values into the equation:

$$\Delta x \geq \frac{6.626 \times 10^{-34}}{4 \times 3.14159 \times (9.1 \times 10^{-31}) \times (5.8 \times 10^{5})}$$

Step 4: Simplify the denominator:

$$\text{Denominator} = 12.5664 \times 9.1 \times 5.8 \times 10^{-26} \approx 663.25 \times 10^{-26} \approx 6.6325 \times 10^{-24}$$

Step 5: Perform the division:

$$\Delta x \geq \frac{6.626 \times 10^{-34}}{6.6325 \times 10^{-24}} \approx 0.999 \times 10^{-10} \text{ m} \approx 1.0 \times 10^{-10} \text{ m}$$

Final Answer: $\boxed{1.0 \times 10^{-10} \text{ m}}$

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: The number of radial nodes in any given atomic orbital is determined by the formula:

$$\text{Number of radial nodes} = n - l - 1$$

where:
n is the principal quantum number.
l is the azimuthal quantum number.

Solution: Step 1: Write down the quantum numbers (n, l) and calculate the number of radial nodes for each option: 1s orbital: $n = 1, l = 0$

$$\text{Radial nodes} = 1 - 0 - 1 = 0$$

2p orbital: $n = 2, l = 1$

$$\text{Radial nodes} = 2 - 1 - 1 = 0$$

3s orbital: $n = 3, l = 0$

$$\text{Radial nodes} = 3 - 0 - 1 = 2$$

2s orbital: $n = 2, l = 0$

$$\text{Radial nodes} = 2 - 0 - 1 = 1$$

Step 2: Compare the results. Only the 3s orbital has exactly two radial nodes. A radial probability curve for the 3s orbital would cross the distance axis ($P(r) = 0$) twice, producing three distinct peaks of increasing height.

Final Answer: $\boxed{3s}$

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: According to Molecular Orbital (MO) theory, the bond order of a homonuclear diatomic molecule or ion is calculated as:

$$\text{Bond Order} = \frac{N_b - N_a}{2}$$

where N_b is the number of bonding electrons and N_a is the number of antibonding electrons. The molecular orbital electronic configuration for oxygen-like species (possessing ≥ 14 electrons) is:

$$\sigma^2_{1s}\sigma^{*2}_{1s}\sigma^2_{2s}\sigma^{*2}_{2s}\sigma^2_{2p_z}(\pi^2_{2p_x} = \pi^2_{2p_y})(\pi^{*1}_{2p_x} = \pi^{*1}_{2p_y})$$

Solution: Step 1: Calculate the bond order for each given species: O_2 (16 electrons):

$$\text{Bond Order} = \frac{10 - 6}{2} = 2.0$$

O_2^- (17 electrons):

$$\text{Bond Order} = \frac{10 - 7}{2} = 1.5$$

O_2^+ (15 electrons):

$$\text{Bond Order} = \frac{10 - 5}{2} = 2.5$$

O_2^{2-} (18 electrons):

$$\text{Bond Order} = \frac{10 - 8}{2} = 1.0$$

Step 2: Compare the calculated bond orders. The species O_2^+ has the highest bond order (2.5).

Final Answer: $\boxed{O_2^2+}$

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept: According to VSEPR theory, the molecular shape of IF_5 can be determined by calculating the steric number (number of electron domains) of the central Iodine (I) atom:

$$\text{Steric Number} = \text{Number of bonded atoms} + \text{Number of lone pairs}$$

Solution: Step 1: Determine the number of valence electrons of the central Iodine atom. Since Iodine belongs to group 17, it has 7 valence electrons.

Step 2: Account for bonds and lone pairs. Iodine forms 5 single bonds with 5 fluorine atoms, using 5 of its valence electrons:

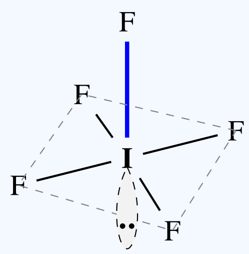
$$\text{Bonded atoms} = 5$$

$$\text{Remaining valence electrons} = 7 - 5 = 2 \implies 1 \text{ lone pair}$$

Step 3: Calculate the steric number:

$$\text{Steric Number} = 5 + 1 = 6$$

Step 4: Determine the geometry. A steric number of 6 corresponds to octahedral electron-pair geometry. Because there are 5 bonding pairs and 1 lone pair, the lone pair occupies one of the axial positions to minimize electron repulsions. This results in a square pyramidal molecular geometry.



Final Answer: Square pyramidal

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: Hydrogen bonding is a strong intermolecular force that arises when hydrogen is covalently bonded to a highly electronegative and small atom such as fluorine, oxygen, or nitrogen. Among the hydrogen halides (HX), only HF forms strong hydrogen bonds because fluorine has:

(a) Very high electronegativity

(b) Very small atomic size

As a result, the H–F bond becomes highly polar, enabling strong intermolecular hydrogen bonding between HF molecules. The other hydrogen halides HCl, HBr, and HI do not form significant hydrogen bonds because their halogen atoms are larger and less electronegative.

Solution: Step 1: Analyze the properties of the given hydrogen halides:

HF:
Fluorine is the most electronegative element and has a very small atomic size. Therefore, the H–F bond is highly polar, leading to strong intermolecular hydrogen bonding between HF molecules.

HCl, HBr, and HI:
Chlorine, bromine, and iodine are larger and less electronegative than fluorine. Hence, these compounds do not exhibit significant hydrogen bonding and are mainly held together by weaker dipole-dipole and van der Waals forces.

Step 2: Analyze the physical state. In the gaseous state, most polar gases exist as independent molecules. However, the hydrogen bonds in gaseous hydrogen fluoride (HF) are so strong that they persist in the gas phase, causing the molecules to exist as associated chain-like or cyclic oligomeric clusters (e.g., $(HF)_6$).

Final Answer: HF

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Le Chatelier's Principle states that if a dynamic equilibrium is disturbed by changing the conditions (temperature, pressure, or concentration), the position of equilibrium will shift in a direction that counteracts the change. For a gaseous system:
An increase in pressure will shift the equilibrium towards the side with fewer moles of gas.
A decrease in pressure will shift the equilibrium towards the side with more moles of gas.

Solution: Step 1: Write down the balanced chemical equation and count the gaseous moles of reactants and products:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

$$\text{Moles of gaseous reactants } = 1 + 3 = 4 \text{ moles}$$

$$\text{Moles of gaseous products } = 2 \text{ moles}$$

Step 2: Analyze the effect of pressure. Since the forward reaction reduces the number of moles of gas (from 4 to 2), increasing the external pressure on the system will shift the equilibrium in the direction that reduces the pressure.

Step 3: Conclude that increasing the pressure shifts the equilibrium in the forward direction, favoring the production of NH_3.

Final Answer: increasing pressure only

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: An enthalpy diagram shows the relative potential energies of reactants and products over the course of a reaction:
Exothermic reaction: The potential energy of the products is lower than the potential energy of the reactants ($\Delta H < 0$).
Endothermic reaction: The potential energy of the products is higher than the potential energy of the reactants ($\Delta H > 0$).
Activation Energy (E_a): The minimum energy barrier that must be overcome for reactants to transform into products.

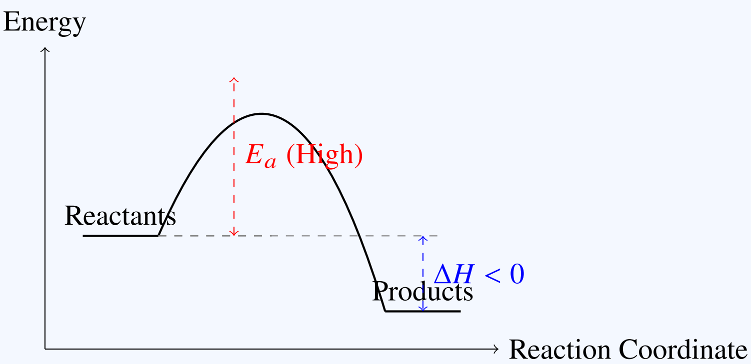
Solution: Step 1: Compare the energy levels of the reactants and products in the diagram: Reactants level ≈ 1.0 Products level ≈ 0.5 Since $E_{\text{Products}} < E_{\text{Reactants}}$, energy is released, and the reaction is exothermic.

Step 2: Evaluate the activation energy (E_a). The peak energy barrier of the transition state is at ≈ 3.5:

$$E_a = E_{\text{peak}} - E_{\text{Reactants}} \approx 3.5 - 1.0 = 2.5 \text{ units}$$

This activation energy barrier is relatively high compared to the net energy released ($|\Delta H| \approx 0.5$ units).

Step 3: Conclude that the reaction is exothermic with a high activation energy.



Final Answer: Exothermic with high activation energy

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: For extremely dilute solutions of strong acids (concentration $\leq 10^{-6}$ M), the concentration of H^+ ions from the autoionization of water cannot be neglected. The total concentration of hydronium ions is:

$$[H^+]_{total} = [H^+]_{acid} + [H^+]_{water}$$

Solution: Step 1: Write down the autoionization equilibrium of water:

$$H_2O(l) \rightleftharpoons H^+(aq) + OH^-(aq)$$

At 298 K, $K_w = [H^+]_{total}[OH^-] = 10^{-14}$.
Step 2: Let x be the concentration of H^+ ions contributed by water. The total concentration of H^+ in the solution is:

$$[H^+]_{total} = (10^{-8} + x)\ \text{M}$$

The concentration of hydroxide ions is:

$$[OH^-] = x\ \text{M}$$

Step 3: Substitute these into the water self-ionization expression:

$$(10^{-8} + x)x = 10^{-14} \implies x^2 + 10^{-8}x - 10^{-14} = 0$$

Step 4: Solve the quadratic equation for x (selecting the physically positive root):

$$x = \frac{-10^{-8} + \sqrt{(10^{-8})^2 - 4(1)(-10^{-14})}}{2}$$

$$x = \frac{-10^{-8} + \sqrt{10^{-16} + 400 \times 10^{-16}}}{2} = \frac{-10^{-8} + \sqrt{401} \times 10^{-8}}{2}$$

$$x \approx \frac{-10^{-8} + 20.025 \times 10^{-8}}{2} \approx 9.51 \times 10^{-8}\ \text{M}$$

Step 5: Calculate the total H^+ concentration:

$$[H^+]_{total} = 10^{-8} + 9.51 \times 10^{-8} = 1.051 \times 10^{-7}\ \text{M}$$

Step 6: Calculate the pH:

$$\text{pH} = -\log_{10}(1.051 \times 10^{-7}) = 7 - \log_{10}(1.051) \approx 7 - 0.02 = 6.98$$

This value is slightly less than 7, which represents a very weakly acidic solution.

Final Answer: slightly less than 7

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Overall Order: The overall order of a chemical reaction is the sum of the partial orders (exponents) of the concentration terms in the experimental rate law:

$$\text{Rate} = k[A]^x[B]^y \implies \text{Overall Order} = x + y$$

Units of k: For a reaction of overall order n, the units of the rate constant k are given by:

$$\text{Units} = \left(\frac{\text{L}}{\text{mol}}\right)^{n-1} \text{s}^{-1} = \text{L}^{n-1}\text{mol}^{1-n}\text{s}^{-1}$$

Solution: Step 1: Identify the rate law given:

$$\text{Rate} = k[A]^2[B]^1$$

Step 2: Calculate the overall order (n) of the reaction by summing the exponents:

$$\text{Overall Order } (n) = 2 + 1 = 3$$

Step 3: Find the units of the rate constant k for a third-order reaction ($n = 3$):

$$\text{Units of } k = \left(\frac{\text{L}}{\text{mol}}\right)^{3-1} \text{s}^{-1} = \text{L}^2\text{mol}^{-2}\text{s}^{-1}$$

Final Answer: $\boxed{3\ ;\ \text{L}^2\ \text{mol}^{-2}\ \text{s}^{-1}}$

Answer: (B)

Go Back to Question 10

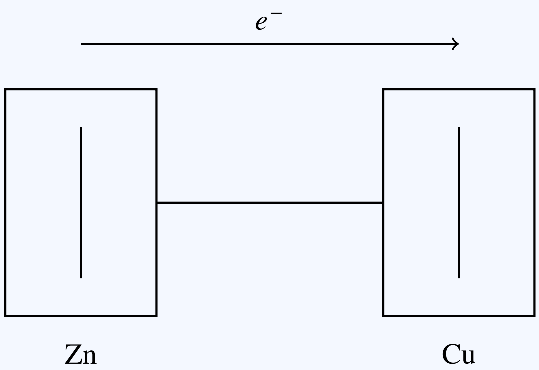
Q11.

Solution

Concept: In any electrochemical (galvanic) cell:
The electrode where oxidation occurs is the anode (negative terminal).
The electrode where reduction occurs is the cathode (positive terminal).
Electrons flow through the external circuit from the anode to the cathode.
For a Zn–Cu cell, Zinc is more reactive than Copper ($E^\circ_{Zn^{2+}/Zn} = -0.76$ V and $E^\circ_{Cu^{2+}/Cu} = +0.34$ V).
Therefore, Zinc acts as the anode (undergoes oxidation) and Copper acts as the cathode (undergoes reduction).

Solution: Step 1: Identify the components and direction of electron flow from the diagram:
Left electrode: Zinc (Zn)
Right electrode: Copper (Cu)
The arrow represents the electron flow in the external circuit, pointing from Zn to Cu.

Step 2: Evaluate the statements:
(A) Cu acts as anode — Incorrect (Zn is the anode).
(B) Zn undergoes reduction — Incorrect (Zn undergoes oxidation to form Zn^{2+}).
(C) electrons flow from Zn to Cu — Correct, as indicated by the electron flow direction arrow in the diagram.
(D) oxidation occurs at Cu electrode — Incorrect (reduction occurs at the Cu cathode).



Final Answer: electrons flow from Zn to Cu

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: The van 't Hoff factor (i) is the number of particles (ions or molecules) produced in solution per formula unit of solute. For strong electrolytes, i is equal to the number of ions produced upon complete dissociation. For non-electrolytes, $i = 1$.

Solution: Step 1: Determine the van 't Hoff factor i for each compound assuming complete dissociation in aqueous solution:
NaCl: Dissociates into Na^+ and Cl^- (2 ions) $\implies i = 2$.
K_2SO_4: Dissociates into $2K^+$ and SO_4^{2-} (3 ions) $\implies i = 3$.
Glucose: Does not dissociate (non-electrolyte) $\implies i = 1$.
Urea: Does not dissociate (non-electrolyte) $\implies i = 1$.

Step 2: Compare the values. K_2SO_4 produces the maximum number of ions per formula unit, giving it the maximum van 't Hoff factor.

Final Answer: $\boxed{K_2SO_4}$

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Baeyer's reagent is a cold, dilute, alkaline solution of potassium permanganate ($KMnO_4$). It is a mild oxidizing agent that reacts with alkenes to add two hydroxyl groups (–OH) across the double bond via syn-addition (syn-dihydroxylation) to yield a vicinal diol.

Solution: Step 1: Write down the reaction equation of propene with Baeyer's reagent:

$$CH_3CH = CH_2 + H_2O + [O] \xrightarrow{\text{cold alkaline } KMnO_4} CH_3CH(OH)CH_2OH$$

Step 2: Identify the product. The compound $CH_3CH(OH)CH_2OH$ contains three carbons with hydroxyl groups at positions 1 and 2.

Step 3: Its systematic IUPAC name is propane-1,2-diol.

Final Answer: $\boxed{\text{Propane-1,2-diol}}$

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: The acid-catalyzed dehydration of alcohols to form alkenes proceeds via a carbocation intermediate (E1 mechanism). The rate-determining step is the formation of the carbocation. Thus, the ease of dehydration is directly proportional to the stability of the intermediate carbocation:

$$\text{Tertiary } (3^\circ) > \text{Secondary } (2^\circ) > \text{Primary } (1^\circ)$$

Solution: Step 1: Classify each of the given alcohols:
Ethanol (CH_3CH_2OH): Primary (1°) alcohol.
Propan-1-ol ($CH_3CH_2CH_2OH$): Primary (1°) alcohol.
Propan-2-ol ($CH_3CH(OH)CH_3$): Secondary (2°) alcohol.
tert-Butyl alcohol ($(CH_3)_3COH$): Tertiary (3°) alcohol.

Step 2: Evaluate the carbocation stability. The dehydration of *tert*-butyl alcohol forms the highly stable *tert*-butyl carbocation (3°), which is stabilized by nine hyperconjugative hydrogen atoms and $+I$ inductive effects.

Step 3: Conclude that *tert*-butyl alcohol undergoes dehydration most readily.

Final Answer: tert-Butyl alcohol

Answer: (D)

Go Back to Question 14

Q15.

Solution

Concept: Friedel-Crafts alkylation is an electrophilic aromatic substitution reaction. Strongly deactivating groups (like the nitro group, $-NO_2$) withdraw electron density from the benzene ring via resonance (–R) and inductive (–I) effects, making the ring too electron-deficient to react with electrophiles. Additionally, the Lewis acid catalyst ($AlCl_3$) complexes with the deactivating group, further deactivating the ring.

Solution: Step 1: Analyze the substituents on the benzene ring for each option:
Benzene: Unsubstituted, undergoes reaction.
Chlorobenzene: Weakly deactivated, but still undergoes Friedel-Crafts reactions.
Nitrobenzene: Strongly deactivated by the electron-withdrawing nitro group ($-NO_2$).
Toluene: Activated by the electron-donating methyl group ($-CH_3$), undergoes reaction very readily.

Step 2: Identify the unreactive compound. Due to severe deactivation of the ring, nitrobenzene will not undergo Friedel-Crafts alkylation.

Final Answer: Nitrobenzene

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Aldehydes (such as ethanal, CH_3CHO) are easily oxidized to carboxylic acids, whereas ketones (such as propanone, CH_3COCH_3) resist oxidation. Consequently, mild oxidizing reagents are used to chemically distinguish between them.

Solution: Step 1: Evaluate each reagent: Tollens' reagent: A mild oxidizing agent that reacts with aldehydes to produce a silver mirror, but does not react with ketones. Fehling's solution: A mild oxidizing agent that oxidizes aliphatic aldehydes to form a red precipitate of cuprous oxide (Cu_2O), but does not react with ketones. Schiff's reagent: Restores its pink/magenta color upon reaction with aldehydes, but remains colorless with ketones.
Step 2: Since all of the listed reagents can be used to distinguish between an aldehyde (ethanal) and a ketone (propanone), the correct choice is "All of these".

Final Answer: All of these

Answer: (D)

Go Back to Question 16

Q17.

Solution

Concept: The amino group ($-NH_2$) in aniline is a highly activating and strongly *ortho*/*para*-directing group due to the strong resonance donation of the nitrogen lone pair. Because the benzene ring is highly activated, electrophilic aromatic substitution with bromine water ($Br_2(aq)$) occurs rapidly and simultaneously at all available *ortho* and *para* positions.

Solution: Step 1: Write down the reaction equation:

$$C_6H_5NH_2 + 3Br_2(aq) \longrightarrow \text{2,4,6-tribromoaniline} \downarrow + 3HBr$$

Step 2: Identify the product. Bromination of aniline with bromine water is so rapid that it does not stop at mono-substitution. It yields a white precipitate of 2,4,6-tribromoaniline.

Final Answer: 2,4,6-tribromoaniline

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: Packing efficiency is the percentage of total volume in a crystal unit cell occupied by the constituent spheres (atoms/ions):

$$\text{Packing Efficiency} = \frac{\text{Volume occupied by spheres in unit cell}}{\text{Total volume of unit cell}} \times 100\%$$

Solution: Step 1: Recall the parameter values for a body-centered cubic (bcc) unit cell:
Number of atoms per unit cell (Z) = 2.
Relation between edge length a and atomic radius r: $r = \frac{\sqrt{3}}{4}a$.

Step 2: Calculate the volume occupied by the spheres:

$$V_{\text{spheres}} = 2 \times \frac{4}{3}\pi r^3 = \frac{8}{3}\pi\left(\frac{\sqrt{3}}{4}a\right)^3 = \frac{\sqrt{3}\pi}{8}a^3$$

Step 3: Divide by the total unit cell volume ($V_{\text{cell}} = a^3$):

$$\text{Packing Efficiency} = \frac{\frac{\sqrt{3}\pi}{8}a^3}{a^3} \times 100\% = \frac{\sqrt{3}\pi}{8} \times 100\% \approx 68.02\%$$

Thus, the packing efficiency is approximately 68%.

Final Answer: $\boxed{68\%}$

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Density is defined as mass per unit volume. Any point defect in a crystal lattice that results in a loss of constituent atoms/ions from the crystal unit cell decreases its mass and, consequently, its overall density.

Solution: Step 1: Analyze the effects of the given defects on density:
Frenkel defect: Ions are only displaced from their regular lattice sites to nearby interstitial sites. Since no ions leave the crystal, the total mass and volume remain constant, meaning density is unchanged.
Schottky defect: An equal number of cations and anions are completely missing from their normal lattice sites to maintain charge neutrality. Since ions are lost from the crystal, mass decreases while volume is constant, causing a decrease in density.
Interstitial defect: Extra constituent particles occupy interstitial spaces, increasing the overall mass and thus increasing the density.

Step 2: Conclude that the Schottky defect decreases the density of the crystal.

Final Answer: Schottky defect

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Hydration enthalpy is the energy released when one mole of gaseous ions undergoes hydration. It is determined by the charge density of the ion:

$$\text{Hydration Enthalpy} \propto \frac{\text{Charge}}{\text{Size}}$$

For ions of identical charge, hydration enthalpy is inversely proportional to the ionic radius. A smaller ion has a higher charge density, allowing it to polarize and attract water dipoles more strongly.

Solution: Step 1: Compare the ionic sizes of the alkali metal cations:

$$Li^+ < Na^+ < K^+ < Rb^+$$

Step 2: Identify the ion with the highest charge density. Since all ions carry a +1 charge, the smallest ion, Li^+, possesses the highest charge density.

Step 3: Conclude that Li^+ undergoes the strongest hydration, thereby releasing the maximum hydration enthalpy.

Final Answer: $\boxed{Li^+}$

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: When excess ammonia (NH_3) is added to an aqueous copper(II) sulfate ($CuSO_4$) solution, a ligand substitution reaction occurs. The water molecules coordinated to the copper ion are replaced by ammonia ligands to form a highly stable, deep blue (or royal blue) coordination complex called the tetraamminecopper(II) ion:

$$[Cu(H_2O)_4]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} + 4H_2O$$

Solution: Step 1: Write down the chemical process. Adding a small amount of ammonia first precipitates light-blue copper(II) hydroxide:

$$Cu^{2+}(aq) + 2OH^-(aq) \longrightarrow Cu(OH)_2(s) \downarrow$$

Step 2: Adding excess ammonia dissolves the precipitate to form a deep blue, clear solution of the tetraamminecopper(II) complex:

$$Cu(OH)_2(s) + 4NH_3(aq) \longrightarrow [Cu(NH_3)_4]^{2+}(aq) + 2OH^-(aq)$$

Step 3: Identify the complex ion responsible for the deep blue color. This is the square-planar tetraamminecopper(II) ion, represented as $[Cu(NH_3)_4]^{2+}$.

Final Answer: $\boxed{[Cu(NH_3)_4]^{2+}}$

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: The first ionization enthalpy ($\Delta_i H$) is the minimum energy required to remove the most loosely bound electron from an isolated neutral gaseous atom:

$$X(g) \rightarrow X^+(g) + e^-$$

Across a period, ionization enthalpy generally increases due to:

(a) Increase in effective nuclear charge

(b) Decrease in atomic size

However, atoms possessing extra stable half-filled or fully-filled electronic configurations exhibit unusually high ionization enthalpies because such configurations are energetically more stable.

Solution: Step 1: Write down the ground-state electronic configurations for the given second-period elements:
Boron (B): $1s^2 2s^2 2p^1$ (Group 13)
Beryllium (Be): $1s^2 2s^2$ (Group 2) — Has a stable, fully-filled $2s^2$ subshell.
Carbon (C): $1s^2 2s^2 2p^2$ (Group 14)
Nitrogen (N): $1s^2 2s^2 2p^3$ (Group 15) — Has a highly stable, half-filled $2p^3$ subshell.

Step 2: Analyze the ionization trends:
Going from left to right: B < Be < C < N.
Beryllium ($\approx$ 899 kJ/mol) has a higher ionization energy than Boron ($\approx$ 801 kJ/mol) because it is harder to remove an electron from a stable, fully-filled $2s^2$ orbital compared to the $2p^1$ orbital of Boron.
Nitrogen ($\approx$ 1402 kJ/mol) has a significantly higher ionization energy than Carbon ($\approx$ 1086 kJ/mol) due to its larger nuclear charge and the extra stability of its half-filled $2p^3$ subshell.

Step 3: Compare all values. Nitrogen has the highest first ionization enthalpy among the given options.

Final Answer: N

Answer: (D)

Go Back to Question 22

Q23.

Solution

Concept: The reaction of phenol with chloroform ($CHCl_3$) in the presence of an aqueous alkali like sodium hydroxide (NaOH) introduces a formyl group (–CHO) onto the benzene ring, primarily at the *ortho* position. This organic transformation is known as the Reimer-Tiemann reaction.

Solution: Step 1: Write down the chemical equation for the Reimer-Tiemann reaction:

$$C_6H_5OH + CHCl_3 + 3NaOH \longrightarrow o\text{-}C_6H_4(OH)(CHO) + 3NaCl + 2H_2O$$

Step 2: Identify the major product formed. The reaction introduces a formyl group at the *ortho* position of phenol, yielding 2-hydroxybenzaldehyde, commonly known as salicylaldehyde.

Final Answer: Salicylaldehyde

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept: Aldehydes and ketones undergo nucleophilic addition reactions at the electrophilic carbonyl carbon. When acetaldehyde (CH_3CHO) reacts with hydrogen cyanide (HCN), the cyanide ion (CN^-) acts as a nucleophile, attacking the carbonyl carbon. Subsequent protonation of the oxygen atom yields a compound containing both a hydroxyl group (–OH) and a cyano group (–CN) on the same carbon, which is termed a cyanohydrin.

Solution: Step 1: Write down the step-by-step chemical reaction:
1. Nucleophilic Attack: The nucleophile CN^- attacks the carbonyl carbon of acetaldehyde, breaking the $C = O$ double bond and forming an alkoxide intermediate:

$$CH_3CHO + CN^- \longrightarrow CH_3CH(O^-)CN$$

2. Protonation: The alkoxide intermediate is protonated to yield the final neutral addition product:

$$CH_3CH(O^-)CN + H^+ \longrightarrow CH_3CH(OH)CN$$

Step 2: Identify the product class. The resulting product is acetaldehyde cyanohydrin (IUPAC: 2-hydroxypropanenitrile).

Final Answer: Cyanohydrin

Answer: (A)

Go Back to Question 24

Q25.

Solution

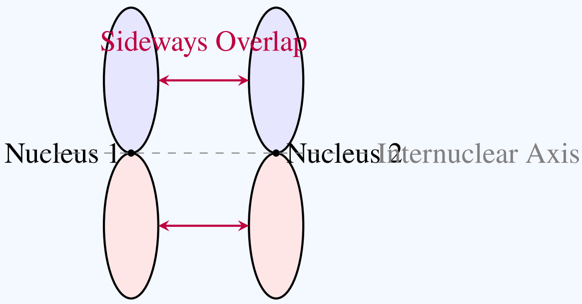
Concept: Covalent bonds are formed by the overlap of atomic orbitals. The overlap can occur in two different ways:

(a) **Head-on (Axial) Overlap:** When atomic orbitals overlap directly along the internuclear axis, a strong σ (sigma) bond is formed.

(b) **Sidewise (Lateral) Overlap:** When two parallel unhybridized orbitals overlap sideways in a direction perpendicular to the internuclear axis, a π (pi) bond is formed. Since the extent of overlap is smaller, a π-bond is weaker than a σ-bond.

Solution: Step 1: Examine the provided schematic diagram:
Two parallel vertical ellipses represent the electron-density lobes of two distinct p-orbitals. The dashed line running vertically between them represents the central boundary or nodal plane. This arrangement depicts the parallel, side-by-side alignment of the orbitals.

Step 2: Relate the diagram to chemical bonding concepts. The parallel side-by-side positioning represents the lateral or sideways overlap of p-orbitals, which leads to the formation of a π (pi) bond.



Final Answer: $\boxed{\pi \text{ overlap of p-orbitals}}$

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: Non-ideal solutions deviate from Raoult's law due to differences in intermolecular forces between unlike and like molecules.

Positive Deviation:

Positive deviation occurs when the intermolecular attraction between unlike molecules $(A - B)$ is weaker than that between like molecules $(A - A)$ and $(B - B)$. As a result, the molecules escape more easily into the vapour phase, causing the vapour pressure to become greater than that predicted by Raoult's law.

Negative Deviation:

Negative deviation occurs when the intermolecular attraction between unlike molecules $(A - B)$ is stronger than that between like molecules $(A - A)$ and $(B - B)$. Consequently, the escaping tendency of the molecules decreases, resulting in a vapour pressure lower than that predicted by Raoult's law.

Solution: Step 1: Analyze each solution: **(A) Acetone + Chloroform:**

This mixture shows negative deviation from Raoult's law because strong hydrogen bonding develops between acetone and chloroform molecules. The intermolecular attraction becomes stronger, reducing the escaping tendency of the molecules and lowering the vapour pressure.

(B) Benzene + Toluene:

This mixture behaves nearly ideally because both liquids possess similar molecular sizes and intermolecular forces. Hence, it shows very little deviation from Raoult's law.

(C) Ethanol + Water:

In pure ethanol, strong hydrogen bonding exists between ethanol molecules. On mixing with water, the ethanol-water interactions become comparatively weaker than the original interactions, increasing the escaping tendency of molecules. Therefore, the mixture shows positive deviation from Raoult's law.

(D) Ethanol + Acetone:

Acetone molecules disrupt the hydrogen bonding present between ethanol molecules. As a result, intermolecular attractions weaken, making vaporization easier and increasing the vapour pressure. Hence, this mixture also shows positive deviation from Raoult's law.

Step 2: Among the given options, ethanol + acetone is the standard textbook example of a solution showing positive deviation from Raoult's law.

Final Answer: Ethanol + acetone

Answer: (D)

Go Back to Question 26

Q27.

Solution

Concept: Teflon (polytetrafluoroethylene, PTFE) is an addition polymer. It is synthesized through the free-radical polymerization of its gaseous monomer, tetrafluoroethene ($CF_2 = CF_2$), under high pressure in the presence of a catalyst (such as a persulfate initiator).

Solution: Step 1: Write down the chemical equation representing the polymerization of Teflon:

$$n(CF_2 = CF_2) \xrightarrow[\text{High Pressure}]{\text{Catalyst, }\Delta} [-CF_2-CF_2-]_n \quad \text{(Teflon)}$$

Step 2: Identify the monomer unit from the chemical equation. The monomer used is tetrafluoroethene ($CF_2 = CF_2$).

Final Answer: Tetrafluoroethene

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: Reducing Sugars: Carbohydrates that can reduce Tollens' reagent or Fehling's solution. This property requires a free (unlocked) carbonyl group, which exists as a hemiacetal or hemiketal group in the cyclic form. Non-reducing Sugars: Carbohydrates that do not reduce these reagents because the carbonyl (anomeric) carbons of their monosaccharide units are joined together by a glycosidic bond, leaving no free hemiacetal or hemiketal groups.

Solution: Step 1: Evaluate each carbohydrate option:
Glucose: Monosaccharide with a free aldehyde group at C_1. It is a reducing sugar.
Maltose: Disaccharide composed of two α-D-glucose units linked by an α-($1 \to 4$) glycosidic bond. The hemiacetal group at C_1 of the second glucose unit remains free. It is a reducing sugar.

Lactose: Disaccharide of β-D-galactose and β-D-glucose linked by a β-($1 \to 4$) glycosidic bond. The hemiacetal group at C_1 of the glucose unit remains free. It is a reducing sugar.

Sucrose: Disaccharide of α-D-glucose and β-D-fructose linked by a glycosidic bond between C_1 of glucose and C_2 of fructose. Since both reactive anomeric carbons are locked in the glycosidic linkage, it lacks free hemiacetal or hemiketal groups. It is a non-reducing sugar.

Final Answer: Sucrose

Answer: (D)

Go Back to Question 28

Q29.

Solution

Concept: The Arrhenius equation describes the quantitative dependence of the reaction rate constant k on absolute temperature T:

$$k = Ae^{-E_a/RT}$$

where A is the pre-exponential factor, E_a is the activation energy, and R is the universal gas constant.

Solution: Step 1: Take the base-10 logarithm on both sides of the Arrhenius equation:

$$\ln k = \ln A - \frac{E_a}{RT}$$

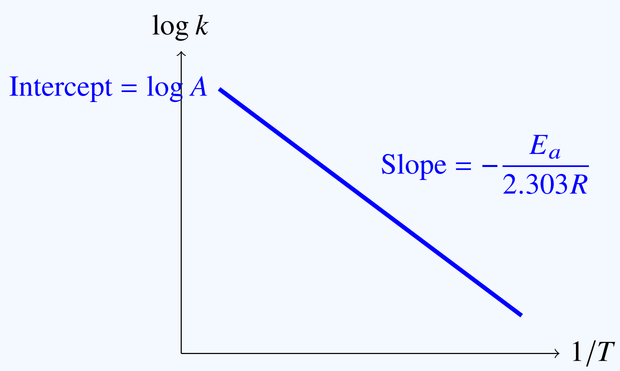
Convert the natural logarithm to base-10 logarithm ($\log_{10}$):

$$2.303 \log k = 2.303 \log A - \frac{E_a}{RT}$$

$$\log k = \log A - \frac{E_a}{2.303R}\left(\frac{1}{T}\right)$$

Step 2: Relate the equation to a straight line ($y = mx + c$): $y = \log k$ $x = \frac{1}{T}$ Slope $m = -\frac{E_a}{2.303R}$ (a constant negative value) y-intercept $c = \log A$

Step 3: Analyze the graph. The plot of $\log k$ versus $\frac{1}{T}$ is a straight line with a negative slope, which is the characteristic plot of the Arrhenius equation.



Final Answer: Arrhenius equation

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Adsorption is classified into two types based on the nature of the forces between the adsorbate and the adsorbent:
1. Physisorption (Physical Adsorption): Involves weak van der Waals forces. It is reversible, has low enthalpy of adsorption (20 – 40 kJ/mol), and forms multimolecular layers.
2. Chemisorption (Chemical Adsorption): Involves chemical bond formation (covalent or ionic) between the adsorbate and adsorbent. It is highly specific, irreversible, has high enthalpy of adsorption (80 – 240 kJ/mol), and forms a monolayer.

Solution: Step 1: Evaluate each statement regarding chemisorption:
(A) It is reversible: Incorrect. Chemisorption involves chemical bond formation and is highly irreversible.
(B) It has low enthalpy of adsorption: Incorrect. The chemical bond formation releases a significant amount of heat, resulting in a high enthalpy of adsorption (80 – 240 kJ/mol).
(C) It forms a monolayer: Correct. Once all the active chemical bonding sites on the adsorbent surface are occupied, no further chemical reaction can occur. Thus, it is limited to a single layer (monolayer).
(D) It decreases with increase in temperature at all temperatures: Incorrect. Because chemisorption requires an activation energy, the rate of chemisorption first increases with temperature (to overcome the activation energy barrier) and then decreases at higher temperatures due to desorption.

Final Answer: It forms a monolayer

Answer: (C)

Go Back to Question 30

Answer Key

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