WBJEE Chemistry Sample Paper-11

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- This paper contains **40** Multiple Choice Questions divided into **3 Sections**.
- **Section 1 (Q1–Q30):** Each correct answer carries **+1 mark**. Incorrect answer: **-0.25** marks. Only **one** correct option.
- **Section 2 (Q31–Q35):** Each correct answer carries **+2 marks**. Incorrect answer: **-0.5** marks. Only **one** correct option.
- **Section 3 (Q36–Q40):** Each correct answer carries **+2 marks**. **No negative marking**. One or **more** correct options may be correct; full marks only if all correct options are marked.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Section–A — 30 Questions × 1 Mark Each
(Negative Marking: -0.25) [Single Correct]

Q1. The de Broglie wavelength associated with an electron accelerated through a potential difference of 150 V is closest to:

(A) 1.0 Å

(B) 0.5 Å

(C) 1.5 Å

(D) 2.0 Å

Q2. For an ideal gas undergoing isothermal reversible expansion, which quantity remains constant?

(A) Internal energy

(B) Enthalpy

(C) Pressure

(D) Entropy

Q3. For the equilibrium $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$, the equilibrium constant K_p is related to K_c by:

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

(B) $K_p = K_c(RT)^{-2}$

(C) $K_p = K_cRT$

(D) $K_p = K_c$

Q4. The number of Faradays required to deposit 54 g of aluminium from Al^{3+} ions is:

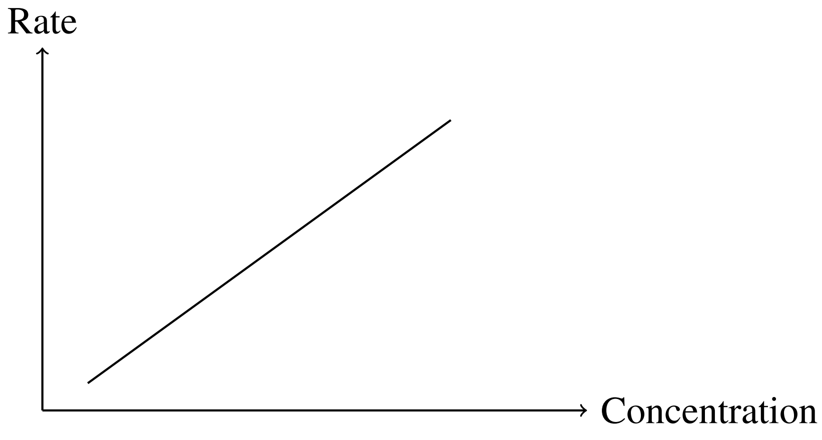
(A) 1

(B) 2

(C) 3

(D) 6

Q5. Refer to the following graph:



The graph represents a reaction which is:

(A) Zero order

(B) First order

(C) Second order

(D) Third order

Q6. Schottky defect decreases the density of a crystal because:

(A) Cations leave lattice

(B) Equal number of ions leave lattice

(C) Interstitial ions are formed

(D) Electrons leave lattice

Q7. The IUPAC name of $K_2[PtCl_6]$ is:

(A) Potassium hexachloroplatinate(IV)

(B) Potassium hexachloroplatinate(II)

(C) Dipotassium platinum chloride

(D) Potassium chloroplatinate

Q8. The major product formed when propanone reacts with methyl magnesium bromide followed by hydrolysis is:

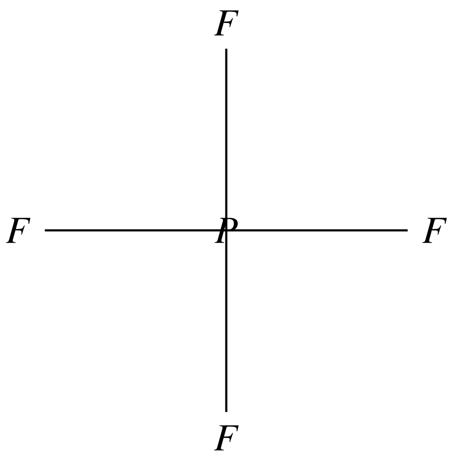
(A) Propan-2-ol

(B) Butan-2-ol

(C) 2-methylpropan-2-ol

(D) Pentan-3-ol

Q9. Refer to the following molecular geometry:



The hybridisation of the central atom is:

(A) sp^3

(B) sp^3d

(C) sp^2

(D) dsp^2

Q10. The major product of hydration of propyne in presence of $HgSO_4/H_2SO_4$ is:

(A) Propanal

(B) Propanone

(C) Propanol

(D) Acetaldehyde

Q11. The bond angle in NH_3 is smaller than that in CH_4 due to:

(A) Presence of lone pair

(B) Presence of double bond

(C) Smaller size of nitrogen

(D) Hydrogen bonding

Q12. The molality of a solution containing 9.8 g H_2SO_4 in 100 g water is:

(A) 0.5 m

(B) 1.0 m

(C) 2.0 m

(D) 0.1 m

Q13. Which colloid is negatively charged?

(A) Ferric hydroxide sol

(B) Arsenious sulphide sol

(C) Aluminium hydroxide sol

(D) Chromium hydroxide sol

Q14. Refer to the following cell:

$$\text{Ag} \mid \text{Ag}^+ \parallel \text{Cu}^{2+} \mid \text{Cu}$$

The cathode in the cell is:

(A) Ag electrode

(B) Cu electrode

(C) Salt bridge

(D) Both electrodes

Q15. Lucas reagent is used to distinguish between:

(A) Aldehydes and ketones

(B) Primary, secondary and tertiary alcohols

(C) Alcohols and phenols

(D) Amines and alcohols

Q16. Among the following hydrides, the strongest reducing agent is:

(A) NH_3

(B) PH_3

(C) AsH_3

(D) SbH_3

Q17. The half-life of a first-order reaction is 20 min. The time required for 87.5% completion is:

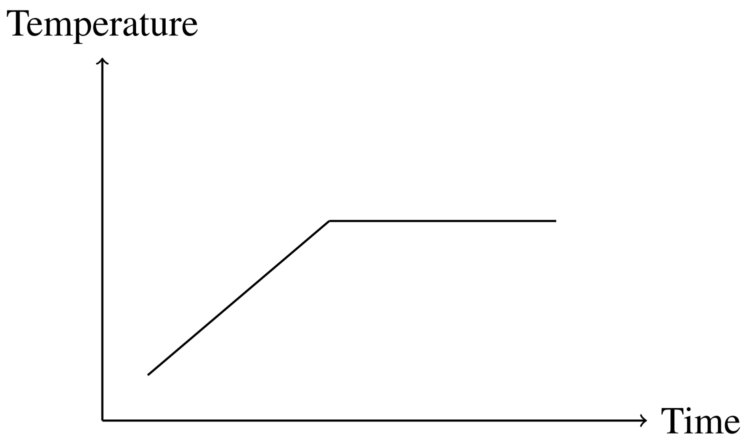
(A) 20 min

(B) 40 min

(C) 60 min

(D) 80 min

Q18. Refer to the following heating curve:



The horizontal portion represents:

(A) Rise in kinetic energy

(B) Phase transition

(C) Cooling process

(D) Increase in pressure

Q19. Aniline on diazotisation followed by treatment with HBF_4 and heating gives:

(A) Chlorobenzene

(B) Bromobenzene

(C) Fluorobenzene

(D) Iodobenzene

Q20. Which element has the highest first ionisation enthalpy?

(A) Li

(B) Be

(C) B

(D) Ne

Q21. The oxidation number of Cr in $K_2Cr_2O_7$ is:

(A) +3

(B) +4

(C) +6

(D) +7

Q22. Which compound undergoes $SN1$ reaction fastest?

(A) Methyl chloride

(B) Ethyl chloride

(C) tert-Butyl chloride

(D) Vinyl chloride

Q23. Refer to the following orbital diagram:

$$\uparrow\downarrow \quad \uparrow \quad \uparrow$$

The total number of unpaired electrons is:

(A) 0

(B) 1

(C) 2

(D) 3

Q24. Which vitamin contains cobalt?

(A) Vitamin A

(B) Vitamin B_{12}

(C) Vitamin C

(D) Vitamin D

Q25. For a spontaneous process at constant temperature and pressure:

(A) $\Delta G > 0$

(B) $\Delta G = 0$

(C) $\Delta G < 0$

(D) $\Delta H = 0$

Q26. The major product obtained on ozonolysis of but-2-ene is:

(A) Methanal

(B) Ethanal

(C) Propanal

(D) Acetone

Q27. Which complex shows geometrical isomerism?

(A) $[Ni(CO)_4]$

(B) $[Pt(NH_3)_2Cl_2]$

(C) $[Co(NH_3)_6]^{3+}$

(D) $[Zn(NH_3)_4]^{2+}$

Q28. Elevation in boiling point depends upon:

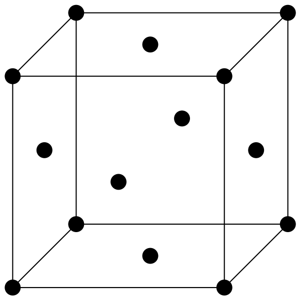
(A) Nature of solvent only

(B) Number of solute particles

(C) Nature of solute only

(D) Pressure only

Q29. Refer to the following crystal arrangement:



The crystal structure is:

(A) Simple cubic

(B) Body-centred cubic

(C) Face-centred cubic

(D) Hexagonal close packed

Q30. Phenol reacts with bromine water to give:

(A) Bromobenzene

(B) 2-bromophenol

(C) 2,4,6-tribromophenol

(D) Bromocyclohexane

Section–B — 5 Questions × 1 Mark Each
(Negative Marking: −0.5) [Single Correct]

Q31. The number of atoms present in 4 g of helium is:

(A) 6.022×10^{23}

(B) 3.011×10^{23}

(C) 12.044×10^{23}

(D) 1.505×10^{23}

Q32. Which molecule has maximum dipole moment?

(A) CO_2

(B) BF_3

(C) NH_3

(D) CCl_4

Q33. Which reagent converts aldehydes into primary alcohols?

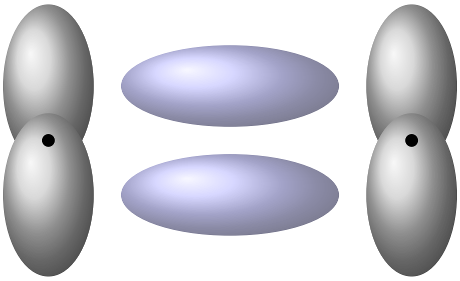
(A) PCC

(B) $LiAlH_4$

(C) Tollens reagent

(D) Fehling solution

Q34. Refer to the following overlap:



π bond formed by sideways overlap of p orbitals

The bond formed is:

(A) Sigma bond

(B) Pi bond

(C) Ionic bond

(D) Coordinate bond

Q35. Which catalyst is used in Haber process?

(A) Ni

(B) Pt

(C) Fe

(D) V_2O_5

Section C — 5 Questions × 2 Marks Each (No Negative Marking) [One or More Correct]

Q36. Which of the following species are isoelectronic with Ne?

(A) Na^+

(B) F^-

(C) Mg^{2+}

(D) Cl^-

Q37. Which of the following compounds exhibit hydrogen bonding?

(A) HF

(B) NH_3

(C) HCl

(D) H_2O

Q38. Which of the following are strong electrolytes?

(A) HCl

(B) NaOH

(C) CH_3COOH

(D) KCl

Q39. Which statements regarding catalysts are correct?

(A) Catalysts increase reaction rate

(B) Catalysts change equilibrium constant

(C) Catalysts lower activation energy

(D) Catalysts remain chemically unchanged after reaction

Q40. Which of the following compounds can undergo aldol condensation?

(A) Ethanal

(B) Acetone

(C) Benzaldehyde

(D) Propanal

Detailed Solutions

Q1.

Solution

Concept: The de Broglie wavelength of a particle is given by:

$$\lambda = \frac{h}{p}$$

For an electron accelerated through a potential difference V:

$$eV = \frac{p^2}{2m}$$

Thus,

$$p = \sqrt{2meV}$$

Substituting into the de Broglie equation:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

Solution: Given:

$$V = 150 \text{ V}$$

Using the de Broglie relation:

$$\lambda = \frac{h}{\sqrt{2meV}}$$

Substituting the values:

$$\lambda = \frac{6.626 \times 10^{-34}}{\sqrt{2 \times 9.109 \times 10^{-31} \times 1.602 \times 10^{-19} \times 150}}$$

$$\lambda \approx 1.0 \times 10^{-10} \text{ m}$$

Since,

$$1 \text{ Å} = 10^{-10} \text{ m}$$

$$\lambda \approx 1.0 \text{ Å}$$

Final Answer: $\boxed{1.0 \text{ Å}}$

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept: For an ideal gas:

$$U = nC_vT$$

Enthalpy is:

$$H = U + PV$$

Using,

$$PV = nRT$$

we get:

$$H = U + nRT = nC_pT$$

Thus, both internal energy and enthalpy depend only on temperature. In an isothermal process, temperature remains constant.

Solution: The gas undergoes an isothermal reversible expansion, so temperature remains constant. For an ideal gas:

$$U = nC_vT$$

Therefore,

$$\Delta U = 0$$

Similarly,

$$H = nC_pT$$

Hence,

$$\Delta H = 0$$

During expansion, volume increases and pressure decreases according to:

$$PV = \text{constant}$$

Entropy increases due to greater randomness of gas molecules. Hence, the quantity that remains constant is internal energy.

Final Answer:

$$\boxed{\text{Internal energy}}$$

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: For a gaseous equilibrium:

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

where

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

Solution: Given equilibrium:

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

Calculate Δn:

$$\Delta n = 2 - (1 + 3)$$

$$\Delta n = -2$$

Using:

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

$$K_p = K_c(RT)^{-2}$$

Final Answer:

$$\boxed{K_p = K_c(RT)^{-2}}$$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: Faraday's laws of electrolysis relate the amount of substance deposited or liberated at an electrode to the quantity of electricity passed through the electrolyte.
The amount of substance deposited is proportional to the quantity of electricity.
The quantity of electricity required to deposit one mole of a substance is equal to $n \times F$, where n is the valency of the ion and F is the Faraday constant (the charge of one mole of electrons).

Solution: Step 1: Identify the ion and its charge.
The ion is Al^{3+}. The charge on the aluminium ion is +3. This means that to form neutral aluminium metal from Al^{3+} ions, each ion needs to gain 3 electrons:

$$Al^{3+} + 3e^{-} \rightarrow Al$$

Step 2: Determine the number of moles of aluminium to be deposited.
The atomic mass of aluminium (Al) is approximately 27 g/mol.
We need to deposit 54 g of aluminium.
Number of moles of Al = $\frac{\text{Mass of Al}}{\text{Atomic mass of Al}} = \frac{54\text{ g}}{27\text{ g/mol}} = 2$ moles

Step 3: Calculate the total charge (in Faradays) required.
From the reaction in Step 1, 1 mole of Al^{3+} ions requires 3 moles of electrons for deposition. This corresponds to 3 Faradays of electricity.
Since we need to deposit 2 moles of aluminium, the total number of Faradays required will be:
Number of Faradays = (Number of moles of Al) × (Number of electrons per mole of Al)
Number of Faradays = 2 moles × 3 Faradays/mole
Number of Faradays = 6 Faradays

Final Answer: $\boxed{6}$

Answer: (D)

Go Back to Question 4

Q5.

Solution

Concept: The rate law relates reaction rate to reactant concentration:

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

where k is the rate constant and n is the order of reaction. Rate vs concentration graphs:

- Zero order: horizontal line
- First order: straight line through origin
- Second order: quadratic curve
- Third order: cubic curve

Solution: The given graph shows the Rate of reaction on the y-axis and Concentration on the x-axis. The graph is a straight line passing through the origin (or very close to it, considering experimental data might not perfectly pass through the origin). The line has a positive slope.

Step 1: Analyze the shape of the graph. The graph is a straight line. This indicates a linear relationship between the rate and the concentration.

Step 2: Determine the relationship between Rate and Concentration from the graph. A straight line passing through the origin with a positive slope signifies that the rate is directly proportional to the concentration.
Mathematically, this can be represented as:

$$\text{Rate} \propto [\text{Concentration}]$$

$$\text{Rate} = k[\text{Concentration}]^1$$

Step 3: Identify the order of the reaction.
A reaction where the rate is directly proportional to the concentration of the reactant is a first-order reaction.

Final Answer: $\boxed{\text{First order}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 5

Q6.

Solution

Concept: A Schottky defect is a point defect in ionic crystals in which equal numbers of cations and anions are missing from their lattice sites, maintaining electrical neutrality. Density is given by:

$$\rho = \frac{\text{mass}}{\text{volume}}$$

In a crystal lattice, formation of Schottky defects reduces the number of ions per unit cell, thereby decreasing the mass while the volume remains almost unchanged, so density decreases.

Solution: Step 1: Understand what a Schottky defect is.
In a Schottky defect, an equal number of cations and anions are missing from their lattice sites. For example, in NaCl, if a Na^+ ion leaves its site, a Cl^- ion also leaves its site to maintain charge balance.

Step 2: Consider the effect of missing ions on the mass of the crystal.
When ions leave the crystal lattice, the total mass of the crystal decreases.
In a Schottky defect, equal numbers of cations and anions are missing from the crystal lattice.
The overall volume of the crystal remains almost unchanged because the lattice structure is not significantly altered; only vacancies are created. Density is given by:

$$\rho = \frac{\text{mass}}{\text{volume}}$$

Since mass decreases due to missing ions while volume remains nearly constant, the density of the crystal decreases.

Step 5: Evaluate the given options.
(A) Cations leave lattice: This is partially true, but anions also leave.
(B) Equal number of ions leave lattice: This is the definition of Schottky defect and leads to a decrease in mass.
(C) Interstitial ions are formed: This describes Frenkel defects, not Schottky defects.
(D) Electrons leave lattice: This is not directly related to Schottky defects.

The primary reason for the decrease in density in a Schottky defect is that mass is lost from the crystal due to the departure of ions from their lattice sites.

Final Answer: $\boxed{\text{Equal number of ions leave lattice}}$

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: IUPAC nomenclature of coordination compounds follows these rules:

1. The cation is named before the anion.
2. Ligands are named in alphabetical order before the metal.
3. Anionic ligands end with "-o" (e.g., chloride → chloro).
4. Greek prefixes (di-, tri-, tetra-) indicate number of ligands; for complex ligands, bis-, tris-, etc. are used.
5. The oxidation state of the metal is written in Roman numerals.
6. If the complex is an anion, the metal name ends with "-ate".

Solution: The compound is $K_2[PtCl_6]$.

Step 1: Identify ions The compound consists of potassium ions (K^+) and the complex anion $[PtCl_6]^{2-}$.

Step 2: Name the cation Potassium is the cation, so it is named first as "potassium".

Step 3: Name the ligands Each ligand is chloride (Cl^-), which is named "chloro" in coordination chemistry. Since there are six such ligands, the prefix "hexachloro" is used.

Step 4: Name the central metal The central metal is platinum. Because the complex is an anion, the metal name changes to "platinate".

Step 5: Oxidation state of Pt Let oxidation state of Pt be x. Each chloride contributes -1, and there are six chlorides. The complex has charge -2.

$$x + 6(-1) = -2$$

$$x - 6 = -2$$

$$x = +4$$

So, platinum is in the +4 oxidation state, written as (IV).

Step 6: Final name Combining all parts in order (cation → ligands → metal with oxidation state):

$$\text{Potassium hexachloroplatinate(IV)}$$

Final Answer: $\boxed{\text{Potassium hexachloroplatinate(IV)}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 7

Q8.

Solution

Concept: Grignard reagents (RMgX) are powerful nucleophiles and bases. When they react with carbonyl compounds like ketones, they undergo nucleophilic addition to the carbonyl carbon. The reaction with a ketone results in the formation of an alkoxide intermediate, which upon hydrolysis yields a tertiary alcohol.

The general reaction of a Grignard reagent with a ketone is:

$$R_2C = O + R'MgX \longrightarrow R_2C(OMgX)R'$$

$$R_2C(OMgX)R' + H_2O \longrightarrow R_2C(OH)R' + Mg(OH)X$$

Solution: The reactant is propanone (acetone), CH_3COCH_3, and the Grignard reagent is CH_3MgBr.

Step 1: Nucleophilic addition The carbonyl group ($C = O$) in propanone is polar, making the carbonyl carbon electrophilic. The methyl group (CH_3^-) from the Grignard reagent acts as a nucleophile and attacks this carbonyl carbon. This breaks the π bond of $C = O$ and forms an alkoxide intermediate:

$$CH_3COCH_3 + CH_3MgBr \longrightarrow (CH_3)_3C - O^- MgBr$$

Step 2: Formation of alkoxide intermediate The oxygen atom now carries a negative charge and is coordinated with $MgBr^+$, giving a magnesium alkoxide complex.

Step 3: Hydrolysis On treatment with dilute acid or water (H_2O/H^+), the alkoxide is protonated:

$$(CH_3)_3C - O^- MgBr + H_2O \longrightarrow (CH_3)_3COH + Mg(OH)Br$$

Step 4: Structure of product The final product has a central carbon bonded to three methyl groups and one hydroxyl group, making it a tertiary alcohol.

Step 5: Naming the product The longest carbon chain contains three carbon atoms (propane). Both the hydroxyl group and methyl group are attached to carbon-2, so the correct IUPAC name is:

2-methylpropan-2-ol

Final Answer: $\boxed{\text{2-methylpropan-2-ol}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 8

Q9.

Solution

Concept: Hybridization is determined using steric number:

$$\text{Steric number} = (\text{sigma bonds}) + (\text{lone pairs})$$

Steric number gives hybridization:

- $2 \longrightarrow sp$
- $3 \longrightarrow sp^2$
- $4 \longrightarrow sp^3$
- $5 \longrightarrow sp^3d$
- $6 \longrightarrow sp^3d^2$

In the given structure, the central atom P is bonded to four F atoms via single bonds, and no lone pairs are present. Therefore, steric number = 4, indicating tetrahedral electron geometry and sp^3 hybridization.

Solution: Step 1: Identify the central atom and the surrounding atoms.
The central atom is 'P' and it is bonded to four 'F' atoms.

Step 2: Determine the number of sigma bonds formed by the central atom.
From the diagram, it is implied that there is a single bond between 'P' and each of the four 'F' atoms. Single bonds are sigma bonds. Therefore, the central atom 'P' forms 4 sigma bonds.

Step 3: Determine the number of lone pairs on the central atom.
The diagram does not show any lone pairs of electrons on the central atom 'P'. We assume there are 0 lone pairs.

Step 4: Calculate the steric number.
Steric Number = (Number of sigma bonds) + (Number of lone pairs)
Steric Number = 4 + 0 = 4

Step 5: Determine the hybridization corresponding to the steric number.
A steric number of 4 corresponds to sp^3 hybridization. This hybridization typically leads to a tetrahedral electron geometry and, if there are no lone pairs, a tetrahedral molecular geometry.

Final Answer: $\boxed{sp^3}$

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: Hydration of alkynes in the presence of $HgSO_4$ and H_2SO_4 produces carbonyl compounds via Markovnikov addition followed by tautomerization.
Mechanism involves:

- Protonation of alkyne to form a vinyl carbocation
- Nucleophilic attack by water
- Tautomerization of enol to ketone

For propyne ($CH_3C \equiv CH$), the reaction follows Markovnikov's rule:

- H adds to the terminal carbon
- OH adds to the internal carbon

This forms an enol intermediate which tautomerizes to a ketone (propanone).

Solution: Propyne is $CH_3C \equiv CH$.

Step 1: Protonation In the presence of acid, H^+ adds to the terminal carbon to form a more stable carbocation intermediate:

$$CH_3C \equiv CH + H^+ \rightarrow CH_3 - C^+ = CH_2$$

Step 2: Nucleophilic attack Water attacks the carbocation to give a protonated enol:

$$CH_3 - C^+ = CH_2 + H_2O \rightarrow CH_3 - C(OH_2^+) = CH_2$$

Step 3: Deprotonation Loss of a proton forms the enol:

$$CH_3 - C(OH_2^+) = CH_2 \rightarrow CH_3 - C(OH) = CH_2$$

Step 4: Tautomerization The enol rearranges to the more stable keto form:

$$CH_3 - C(OH) = CH_2 \rightleftharpoons CH_3 - CO - CH_3$$

Thus, the final product is:

propanone (acetone)

Final Answer: $\boxed{\text{Propanone}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 10

Q11.

Solution

Concept: VSEPR theory explains molecular shapes based on repulsion between electron pairs in the valence shell of the central atom. Electron pairs arrange themselves to minimize repulsion. Order of repulsion:

$$\text{LP–LP} > \text{LP–BP} > \text{BP–BP}$$

For methane (CH_4): Carbon has 4 bonding pairs and no lone pairs. Both electron and molecular geometry are tetrahedral with bond angle 109.5°. For ammonia (NH_3): Nitrogen has 3 bonding pairs and 1 lone pair. Electron geometry is tetrahedral, but molecular geometry is trigonal pyramidal due to lone pair repulsion.

Solution: Step 1: Structure of CH_4 In methane, carbon forms 4 single bonds and has no lone pairs:

- Bonding pairs = 4
- Lone pairs = 0
- Electron groups = 4

Electron geometry is tetrahedral with bond angle 109.5°, and only BP–BP repulsions are present.
Step 2: Structure of NH_3 In ammonia, nitrogen forms 3 bonds and has 1 lone pair:

- Bonding pairs = 3
- Lone pairs = 1
- Electron groups = 4

Electron geometry is also tetrahedral, but molecular geometry is trigonal pyramidal due to the lone pair.
Step 3: Effect of lone pair The lone pair exerts stronger repulsion (LP–BP) compared to BP–BP repulsion in CH_4. This pushes the N–H bonds closer together.
Step 4: Bond angle comparison Due to lone pair repulsion, the bond angle in NH_3 decreases from the ideal 109.5° to about 107°.
Step 5: Correct reason The reduction in bond angle is mainly due to the presence of a lone pair on nitrogen, which increases repulsion and compresses the bond angle.
Final Answer: $\boxed{\text{Presence of lone pair}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 11

Q12.

Solution

Concept: Molality (m) is a measure of the concentration of a solute in a solution. It is defined as the number of moles of solute per kilogram of solvent.

$$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Kilograms of solvent}}$$

Solution: We are given:
Mass of solute (H_2SO_4) = 9.8 g
Mass of solvent (water) = 100 g

Step 1: Calculate the molar mass of the solute (H_2SO_4).
Atomic mass of H = 1.008 g/mol
Atomic mass of S = 32.06 g/mol
Atomic mass of O = 16.00 g/mol
Molar mass of $H_2SO_4 = (2 \times 1.008) + 32.06 + (4 \times 16.00) = 2.016 + 32.06 + 64.00 = 98.076$ g/mol.
We can approximate this to 98 g/mol for simpler calculations.

Step 2: Calculate the number of moles of solute.
Moles of $H_2SO_4 = \frac{\text{Mass of } H_2SO_4}{\text{Molar mass of } H_2SO_4} = \frac{9.8 \text{ g}}{98 \text{ g/mol}} = 0.1$ moles

Step 3: Convert the mass of solvent to kilograms.
Mass of water = 100 g
Mass of water in kg = $\frac{100 \text{ g}}{1000 \text{ g/kg}} = 0.1$ kg

Step 4: Calculate the molality.

$$\text{Molality } (m) = \frac{\text{Moles of solute}}{\text{Kilograms of solvent}} = \frac{0.1 \text{ moles}}{0.1 \text{ kg}} = 1.0 \text{ m}$$

Final Answer: $\boxed{1.0 \text{ m}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 12

Q13.

Solution

Concept: Colloidal sols can be classified as either positively charged or negatively charged based on the charge of the colloidal particles. The charge on colloidal particles arises due to:

1. Adsorption of ions from the medium.
2. Dissociation of polar molecules on the surface of colloidal particles.
3. Ionization of surface atoms.

The charge on a sol is often determined by the nature of the metal oxide or metallic salt used to prepare it and the ions present in the dispersion medium.

Solution: Let's analyze the charge of the colloidal particles in each option:

(A) Ferric hydroxide sol ($Fe(OH)_3$): This sol is prepared by the hydrolysis of ferric chloride ($FeCl_3$). $FeCl_3$ dissociates to give Fe^{3+} ions. These Fe^{3+} ions are preferentially adsorbed on the surface of the precipitated ferric hydroxide particles, making the sol positively charged.

$$Fe^{3+} + 3H_2O \longrightarrow Fe(OH)_3(\text{colloid}) + 3H^+$$

The Fe^{3+} ions are adsorbed: $Fe(OH)_3|Fe^{3+}$

(B) Arsenious sulphide sol (As_2S_3): This sol is prepared by the reaction of arsenious oxide (As_2O_3) with hydrogen sulphide (H_2S). As_2O_3 reacts with H_2S to form As_2S_3. H_2S dissociates to give HS^- and S^{2-} ions. These sulphide ions (S^{2-}) are preferentially adsorbed on the surface of the As_2S_3 particles, making the sol negatively charged.

$$As_2O_3 + 3H_2S \longrightarrow As_2S_3(\text{colloid}) + 3H_2O$$

The S^{2-} ions are adsorbed: $As_2S_3|S^{2-}$

(C) Aluminium hydroxide sol ($Al(OH)_3$): This sol is typically prepared by the hydrolysis of aluminium chloride ($AlCl_3$) or by reacting aluminium metal with hot water. Similar to ferric hydroxide, Al^{3+} ions are preferentially adsorbed, making the sol positively charged.

$$Al^{3+} + 3H_2O \longrightarrow Al(OH)_3(\text{colloid}) + 3H^+$$

The Al^{3+} ions are adsorbed: $Al(OH)_3|Al^{3+}$

(D) Chromium hydroxide sol ($Cr(OH)_3$): This sol is prepared by the hydrolysis of chromium(III) salts (like $CrCl_3$). Similar to ferric and aluminium hydroxide, Cr^{3+} ions are preferentially adsorbed, making the sol positively charged.

$$Cr^{3+} + 3H_2O \longrightarrow Cr(OH)_3(\text{colloid}) + 3H^+$$

The Cr^{3+} ions are adsorbed: $Cr(OH)_3|Cr^{3+}$

From the analysis, arsenious sulphide sol is the negatively charged colloid.

Final Answer: $\boxed{\text{Arsenious sulphide sol}}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: In an electrochemical cell notation (like the one provided), the convention is to represent the anode on the left and the cathode on the right, separated by a salt bridge (represented by ||). The cell is written as: Anode half-cell || Cathode half-cell.
The anode is where oxidation occurs, and the cathode is where reduction occurs.
In the half-cell notation, the electrode is written first, followed by the ion it is in contact with.

Solution: The given cell notation is:

$$\mathrm{Ag} \mid \mathrm{Ag}^{+} \parallel \mathrm{Cu}^{2+} \mid \mathrm{Cu}$$

Step 1: Identify the anode and cathode half-cells based on the cell notation.
The left side of the salt bridge (||) represents the anode half-cell: $\mathrm{Ag} \mid \mathrm{Ag}^{+}$
The right side of the salt bridge (||) represents the cathode half-cell: $\mathrm{Cu}^{2+} \mid \mathrm{Cu}$

Step 2: Determine the electrode at the cathode.
The cathode is the electrode in the cathode half-cell. In the notation $\mathrm{Cu}^{2+} \mid \mathrm{Cu}$, the electrode is Cu. Therefore, the copper electrode is the cathode.

Step 3: Understand the reactions occurring at the cathode.
At the cathode, reduction takes place. For the copper half-cell, the reaction would be:

$$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$$

Step 4: Evaluate the options.
(A) Ag electrode: This is part of the anode half-cell.
(B) Cu electrode: This is part of the cathode half-cell.
(C) Salt bridge: The salt bridge connects the two half-cells and allows ion flow, but it is not an electrode where redox reactions occur.
(D) Both electrodes: Only one electrode acts as the cathode.

Final Answer: $\boxed{\text{Cu electrode}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 14

Q15.

Solution

Concept: Lucas reagent is a solution of anhydrous zinc chloride ($ZnCl_2$) in concentrated hydrochloric acid (HCl). It is used to distinguish between primary, secondary, and tertiary alcohols based on the rate of formation of alkyl chlorides, which are insoluble in the reagent and cause turbidity.
The reactivity order of alcohols with Lucas reagent is:
Tertiary alcohols > Secondary alcohols > Primary alcohols

- Tertiary alcohols react almost instantaneously to form a clear solution (due to rapid formation of insoluble tertiary alkyl chlorides).
- Secondary alcohols react within 5-20 minutes to form turbidity.
- Primary alcohols react very slowly or not at all at room temperature. Heating might be required.

Solution: The Lucas reagent (anhydrous $ZnCl_2$ in concentrated HCl) is a qualitative test to differentiate between different classes of alcohols. The difference in reactivity arises from the stability of the carbocation intermediate formed during the nucleophilic substitution reaction ($SN1$ mechanism).

- Tertiary alcohols form the most stable tertiary carbocations, leading to a very fast reaction and immediate turbidity.
- Secondary alcohols form less stable secondary carbocations, leading to a slower reaction and turbidity appearing within a few minutes.
- Primary alcohols form very unstable primary carbocations, and the reaction is slow at room temperature, often requiring heating.

Final Answer: $\boxed{\text{Primary, secondary and tertiary alcohols}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 15

Q16.

Solution

Concept: The reducing strength of hydrides of Group 15 elements (NH_3, PH_3, AsH_3, SbH_3) increases down the group. This trend is related to the decreasing bond strength between the central atom and hydrogen, and the increasing ease of releasing hydrogen atoms to act as a reducing agent.

The bond dissociation energy of the E-H bond decreases down the group from N to Sb because the size of the central atom increases, leading to weaker overlap and longer bonds. A weaker E-H bond means it is easier to break and release a hydrogen atom, thus increasing reducing strength.

Solution: The hydrides given are NH_3 (ammonia), PH_3 (phosphine), AsH_3 (arsine), and SbH_3 (stibine). These are hydrides of elements in Group 15 of the periodic table.

Step 1: Consider the trend in bond strength down the group.
As we move down Group 15, the atomic size of the central atom (N, P, As, Sb) increases. This leads to an increase in the length of the E-H bond and a decrease in the bond dissociation energy.
- E-H bond strength: $N-H > P-H > As-H > Sb-H$
- Bond dissociation energy: $N-H > P-H > As-H > Sb-H$

Step 2: Relate bond strength to reducing strength.
A reducing agent is a substance that donates electrons or hydrogen atoms. A weaker E-H bond means it is easier to release a hydrogen atom to reduce another species. Therefore, the reducing strength of these hydrides increases as the E-H bond strength decreases.

Step 3: Determine the order of reducing strength.
Based on the decreasing bond strength, the order of reducing strength is:
$SbH_3 > AsH_3 > PH_3 > NH_3$

Step 4: Identify the strongest reducing agent.
The hydride with the weakest E-H bond and thus the strongest reducing ability is SbH_3.

Final Answer: $\boxed{SbH_3}$

Answer: (D)

Go Back to Question 16

Q17.

Solution

Concept: For a first-order reaction:

$$t_{1/2} = \frac{\ln 2}{k}$$

The integrated rate equation is:

$$\ln\left(\frac{[A]_0}{[A]_t}\right) = kt$$

If the reaction is 87.5% complete, then 12.5% of the reactant remains:

$$[A]_t = 0.125[A]_0$$

Thus,

$$\frac{[A]_0}{[A]_t} = \frac{1}{0.125} = 8$$

Solution: Given:

$$t_{1/2} = 20 \text{ min}$$

For a first-order reaction:

$$k = \frac{\ln 2}{t_{1/2}}$$

If the reaction is 87.5% complete, then 12.5% reactant remains:

$$[A]_t = 0.125[A]_0$$

Using:

$$\ln\left(\frac{[A]_0}{[A]_t}\right) = kt$$

$$\ln(8) = \left(\frac{\ln 2}{20}\right)t$$

Since,

$$\ln(8) = 3\ln 2$$

$$3\ln 2 = \left(\frac{\ln 2}{20}\right)t$$

$$t = 60 \text{ min}$$

Alternatively, after 3 half-lives:

$$\left(\frac{1}{2}\right)^3 = \frac{1}{8} = 12.5\%$$

Hence, the reaction is 87.5% complete in 60 min.

Final Answer: $\boxed{60 \text{ min}}$

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: A heating curve represents the change in temperature of a substance as heat is added to it over time. When a substance is heated, its temperature generally increases. However, during a phase transition (like melting or boiling), the energy added is used to overcome the intermolecular forces holding the substance in a particular phase, rather than increasing the kinetic energy of the molecules. This results in a constant temperature during the phase change.

Solution: The provided heating curve shows temperature on the y-axis and time (representing heat added) on the x-axis.

The curve starts with an upward slope, indicating that the temperature is increasing with time. This represents the substance in a single phase absorbing heat and increasing its kinetic energy.

Then, there is a horizontal portion where the temperature remains constant despite heat being added. This indicates that the energy being supplied is not increasing the temperature but is being used for a change of state. This constant temperature corresponds to a phase transition. For a heating curve, this could be melting (solid to liquid) or boiling (liquid to gas).

After the horizontal portion, the temperature starts to rise again, indicating that the substance has completed its phase transition and is now in a new phase, absorbing heat and increasing its kinetic energy.

Step 1: Identify the horizontal portion of the heating curve.
The horizontal line segment in the graph represents a period where the temperature is constant.

Step 2: Understand what happens during a phase transition.
During a phase transition (e.g., melting or boiling), the absorbed heat energy is used to break intermolecular bonds, changing the state of matter, but the temperature remains constant.

Step 3: Relate the horizontal portion to the concept of phase transition.
Therefore, the horizontal portion of the heating curve represents a phase transition.

Final Answer: $\boxed{\text{Phase transition}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 18

Q19.

Solution

Concept: Diazotization of primary aromatic amines (like aniline) followed by treatment with tetrafluoroboric acid (HBF_4) produces a diazonium tetrafluoroborate salt. This salt can then be heated to undergo decomposition, yielding an aryl fluoride. This reaction is known as the Schiemann reaction.

The general reaction sequence is:
1. Diazotization: $\text{ArNH}_2 + NaNO_2 + 2HX \longrightarrow [\text{ArN}_2]^+X^- + NaX + 2H_2O$
2. Formation of diazonium tetrafluoroborate: $[\text{ArN}_2]^+X^- + HBF_4 \longrightarrow [\text{ArN}_2]^+BF_4^- + HX$
3. Thermal decomposition: $[\text{ArN}_2]^+BF_4^- \xrightarrow{\Delta} \text{ArF} + N_2 + BF_3$

Solution: The starting material is aniline ($C_6H_5NH_2$).

Step 1: Diazotization of aniline.
Aniline reacts with sodium nitrite ($NaNO_2$) and hydrochloric acid (HCl) at low temperatures (0-5°C) to form benzenediazonium chloride.

$$C_6H_5NH_2 + NaNO_2 + 2HCl \xrightarrow{0-5^\circ C} [C_6H_5N_2]^+Cl^- + NaCl + 2H_2O$$

Step 2: Treatment with tetrafluoroboric acid (HBF_4).
The benzenediazonium chloride is then treated with tetrafluoroboric acid. This leads to the precipitation of the relatively stable benzenediazonium tetrafluoroborate salt.

$$[C_6H_5N_2]^+Cl^- + HBF_4 \longrightarrow [C_6H_5N_2]^+BF_4^- \downarrow + HCl$$

Step 3: Thermal decomposition of the diazonium tetrafluoroborate salt (Schiemann reaction).
When benzenediazonium tetrafluoroborate is heated, it decomposes to form fluorobenzene, nitrogen gas, and boron trifluoride.

$$[C_6H_5N_2]^+BF_4^- \xrightarrow{\Delta} C_6H_5F + N_2\uparrow + BF_3$$

Therefore, the final product is fluorobenzene.

Final Answer: $\boxed{\text{Fluorobenzene}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 19

Q20.

Solution

Concept: Ionization enthalpy is the energy required to remove the outermost electron from an isolated gaseous atom. General trends:

- Increases across a period due to increasing effective nuclear charge
- Decreases down a group due to larger atomic size and shielding effect

Some exceptions occur because half-filled and fully-filled orbitals are more stable.

Solution: Second period elements:

- Li: $1s^2 2s^1$
- Be: $1s^2 2s^2$
- B: $1s^2 2s^2 2p^1$
- Ne: $1s^2 2s^2 2p^6$

Ionization enthalpy generally increases across a period.
Be has higher ionization enthalpy than B because the fully filled $2s^2$ configuration of Be is more stable, while the $2p^1$ electron of B is easier to remove.
Ne has the highest ionization enthalpy due to its completely filled outer shell.
Step 1: Compare the ionization enthalpies based on the general trend across a period.
Ionization enthalpy generally increases from Li to Ne.

Step 2: Consider the exceptions due to electron configuration.
- Be ($2s^2$) has higher ionization enthalpy than B ($2s^2 2p^1$) because the $2s^2$ configuration is more stable than having a partially filled $2p$ subshell.
- Ne ($2s^2 2p^6$) has a fully filled outer shell, which is exceptionally stable, leading to a very high ionization enthalpy.

Step 3: Order the ionization enthalpies.
Based on the above considerations, the order of first ionization enthalpy is: $Li < B < Be < Ne$

Therefore, Neon (Ne) has the highest first ionization enthalpy among the given elements due to its stable, completely filled electron configuration.

Final Answer: $\boxed{Ne}$

Answer: (D)

Go Back to Question 20

Q21.

Solution

Concept: Oxidation number is the hypothetical charge assigned to an atom assuming all bonds are ionic. Rules for assigning oxidation number:

- Alkali metals: $+1$
- Alkaline earth metals: $+2$
- Oxygen: usually -2
- Hydrogen: $+1$ with nonmetals, -1 with metals
- Sum of oxidation numbers in a neutral compound is zero
- Sum in a polyatomic ion equals its charge

Solution: For $K_2Cr_2O_7$:

- Oxidation number of $K = +1$
- Oxidation number of $O = -2$

Let the oxidation number of Cr be x. Since the compound is neutral:

$$2(+1) + 2x + 7(-2) = 0$$

$$2 + 2x - 14 = 0$$

$$2x = 12$$

$$x = +6$$

Therefore, the oxidation number of Cr is:

$$\boxed{+6}$$

Final Answer: $\boxed{+6}$

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept: $SN1$ reactions proceed through a carbocation intermediate, and the reaction rate depends on the stability of the carbocation formed. Carbocation stability follows the order:

$$3^\circ > 2^\circ > 1^\circ > \text{methyl}$$

Tertiary carbocations are most stable due to the inductive effect and hyperconjugation provided by alkyl groups.

Solution: We need to identify which of the given compounds will form the most stable carbocation upon loss of the leaving group (chloride in this case).

Step 1: Identify the leaving group and the type of carbocation formed by each compound.
- Methyl chloride (CH_3Cl): Loses Cl^- to form a methyl carbocation (CH_3^+). This is a primary (1°) carbocation.
- Ethyl chloride (CH_3CH_2Cl): Loses Cl^- to form an ethyl carbocation ($CH_3CH_2^+$). This is a primary (1°) carbocation.
- tert-Butyl chloride ($(CH_3)_3CCl$): Loses Cl^- to form a tert-butyl carbocation ($(CH_3)_3C^+$). This is a tertiary (3°) carbocation.
- Vinyl chloride ($CH_2 = CHCl$): Loses Cl^- to form a vinyl carbocation ($CH_2 = CH^+$). This carbocation is unstable due to the adjacent double bond, which requires the positive charge to be on an sp^2 hybridized carbon, and the positive charge destabilizes the pi system.

Step 2: Compare the stability of the carbocations formed.
- Methyl carbocation (CH_3^+): Primary (1°) - Least stable among primary and tertiary.
- Ethyl carbocation ($CH_3CH_2^+$): Primary (1°) - Similar stability to methyl carbocation, but slightly more stable due to hyperconjugation from the methyl group.
- tert-Butyl carbocation ($(CH_3)_3C^+$): Tertiary (3°) - Most stable due to the inductive effect and hyperconjugation from three methyl groups.
- Vinyl carbocation ($CH_2 = CH^+$): Highly unstable.

Step 3: Determine which compound undergoes $SN1$ reaction fastest. The compound that forms the most stable carbocation will undergo the $SN1$ reaction fastest. The tert-butyl carbocation is the most stable among the options.

Therefore, tert-butyl chloride will undergo $SN1$ reaction fastest.

Final Answer: $\boxed{\text{tert-Butyl chloride}}$

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept: Unpaired electrons are electrons that occupy an atomic orbital by themselves. In an orbital diagram, electrons are represented by arrows. A single arrow in an orbital indicates an unpaired electron. A pair of arrows (one up, one down) in an orbital indicates a paired electron. Hund's rule states that electrons will singly occupy degenerate orbitals before they pair up.

Solution: The given orbital diagram shows the occupancy of orbitals:

$$\uparrow\downarrow \quad \uparrow \quad \uparrow$$

Step 1: Interpret the diagram.
The first orbital (leftmost) has two arrows pointing in opposite directions, indicating a pair of electrons. These electrons are paired.
The second orbital (middle) has a single upward-pointing arrow, indicating one electron. This electron is unpaired.
The third orbital (rightmost) has a single upward-pointing arrow, indicating one electron. This electron is unpaired.

Step 2: Count the number of unpaired electrons.
- The first orbital has 0 unpaired electrons.
- The second orbital has 1 unpaired electron.
- The third orbital has 1 unpaired electron.

Total number of unpaired electrons = 0 + 1 + 1 = 2.

Final Answer: $\boxed{2}$

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept: Vitamins are essential organic compounds required in small amounts for normal metabolism. Among vitamins:

- Vitamin A is a hydrocarbon derivative
- Vitamin C is an organic acid
- Vitamin D is a sterol derivative
- Vitamin B_{12} contains cobalt metal in its structure

Vitamin B_{12} is unique because it contains a cobalt ion coordinated within a corrin ring.

Solution: We need to identify which vitamin among the given options contains cobalt.

- Vitamin A does not contain any metal.
- Vitamin B_{12} (Cobalamin) is characterized by the presence of a cobalt atom at its center. The name "cobalamin" itself hints at the presence of cobalt.
- Vitamin C (Ascorbic Acid) does not contain any metal.
- Vitamin D (e.g., Cholecalciferol) is a steroid derivative and does not contain any metal.

Therefore, Vitamin B_{12} is the vitamin that contains cobalt.

Final Answer: $\boxed{\text{Vitamin } B_{12}}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: The spontaneity of a process at constant temperature and pressure is determined by the change in Gibbs Free Energy (ΔG).
The relationship is given by:

$$\Delta G = \Delta H - T\Delta S$$

where:
- ΔG is the change in Gibbs Free Energy.
- ΔH is the change in enthalpy.
- T is the absolute temperature.
- ΔS is the change in entropy.

For a process to be spontaneous, the Gibbs Free Energy must decrease, meaning ΔG must be negative.
- If $\Delta G < 0$, the process is spontaneous.
- If $\Delta G = 0$, the process is at equilibrium.
- If $\Delta G > 0$, the process is non-spontaneous (the reverse process is spontaneous).

Solution: The question asks for the condition for a spontaneous process at constant temperature and pressure.

According to the Gibbs Free Energy criterion for spontaneity:
- A process is spontaneous if $\Delta G < 0$.
- A process is at equilibrium if $\Delta G = 0$.
- A process is non-spontaneous if $\Delta G > 0$.

The question specifies a spontaneous process. Therefore, the change in Gibbs Free Energy must be negative.

Final Answer: $\boxed{\Delta G < 0}$

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept: Ozonolysis is the cleavage of an alkene double bond using ozone (O_3), producing carbonyl compounds such as aldehydes or ketones. Product formation depends on the type of carbon atoms attached to the double bond:

- Secondary-secondary ⟶ ketones
- Primary-secondary ⟶ aldehyde + ketone
- Primary-primary ⟶ formaldehyde
- Tertiary-tertiary ⟶ ketones

Solution: The reactant is but-2-ene. The structural formula of but-2-ene is:

$$CH_3 - CH = CH - CH_3$$

This is an alkene where the double bond is between the second and third carbon atoms. Both of these carbon atoms are secondary carbons (each is bonded to two other carbon atoms).

Step 1: Visualize the cleavage of the double bond.
The double bond in but-2-ene is between the two -CH- groups.

$$CH_3 - \underline{CH = CH} - CH_3$$

When ozonolysis occurs, this double bond is broken.

Step 2: Determine the fragments formed.
Upon cleavage, each carbon atom that was part of the double bond forms a carbonyl group ($C = O$).
The fragment on the left is derived from $CH_3 - CH =$, which becomes $CH_3 - CH = O$.
The fragment on the right is derived from $= CH - CH_3$, which becomes $= O - CH - CH_3$.
Combining these, we get two molecules of ethanal (acetaldehyde).

$$CH_3 - CH = O \quad \text{and} \quad O = CH - CH_3$$

Step 3: Identify the product. Both fragments are ethanal (CH_3CHO).
Final Answer: $\boxed{\text{Ethanal}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 26

Q27.

Solution

Concept: Geometrical isomerism arises due to different spatial arrangements of ligands around the central metal atom. It is commonly observed in square planar and octahedral complexes. For square planar complexes of type MA_2B_2:

- cis-isomer: similar ligands are adjacent
- trans-isomer: similar ligands are opposite

For octahedral complexes:

- MA_4B_2 shows cis and trans forms
- MA_3B_3 shows fac and mer isomerism

Solution: Let's analyze each complex:

(A) $[Ni(CO)_4]$: This is a tetrahedral complex (sp^3 hybridization for Ni). In tetrahedral complexes, all ligand positions are equivalent, so geometrical isomerism is not possible.

(B) $[Pt(NH_3)_2Cl_2]$: This is a square planar complex (Pt in +2 oxidation state typically forms square planar complexes, dsp^2 hybridization). It has two ammonia ligands (NH_3) and two chloride ligands (Cl^-). This is of the type MA_2B_2.
- cis isomer: The two NH_3 ligands are adjacent.
- trans isomer: The two NH_3 ligands are opposite.
- Similarly, the two Cl^- ligands can be cis or trans.

Thus, this complex exhibits geometrical isomerism.

(C) $[Co(NH_3)_6]^{3+}$: This is an octahedral complex. It has six identical ammonia ligands. Since all ligands are identical, geometrical isomerism is not possible.

(D) $[Zn(NH_3)_4]^{2+}$: This is a tetrahedral complex (sp^3 hybridization for Zn). Similar to $[Ni(CO)_4]$, all ligand positions are equivalent in tetrahedral geometry, so geometrical isomerism is not possible.

Therefore, $[Pt(NH_3)_2Cl_2]$ is the complex that shows geometrical isomerism.

Final Answer: $\boxed{[Pt(NH_3)_2Cl_2]}$

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: Elevation in boiling point is a colligative property and is given by:

$$\Delta T_b = K_b \, m \, i$$

where K_b is the ebullioscopic constant, m is molality, and i is the van't Hoff factor. The value of i depends on the number of particles formed in solution.

Solution: Step 1: Understand the definition of colligative properties.
Colligative properties (like boiling point elevation, freezing point depression, osmotic pressure, and vapor pressure lowering) depend on the number of solute particles in the solution.

Step 2: Analyze the factors affecting boiling point elevation.
The formula $\Delta T_b = K_b \cdot m \cdot i$ shows that the elevation in boiling point depends on:
- K_b: This is a property of the solvent.
- m: This is the molality, which is moles of solute per kg of solvent, thus related to the amount of solute and solvent.
- i: This is the van't Hoff factor, which depends on the number of particles the solute dissociates into.

Step 3: Relate these factors to the given options.
- Nature of solvent only: While the solvent's nature determines K_b, the elevation also depends on the solute.
- Number of solute particles: This is directly represented by $m \cdot i$. A higher number of solute particles (either due to more moles of solute or greater dissociation/association) leads to a greater boiling point elevation.
- Nature of solute only: The nature of the solute matters if it determines i (e.g., an electrolyte vs. a non-electrolyte), but fundamentally it's the number of particles that counts.
- Pressure only: Pressure significantly affects the boiling point itself but is not the direct factor determining the *elevation* caused by a solute at a given pressure. The question implies standard conditions unless otherwise stated.

The most fundamental factor determining the elevation is the number of solute particles that are dispersed in the solvent.

Final Answer: $\boxed{\text{Number of solute particles}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 28

Q29.

Solution

Concept: Crystal structures describe the arrangement of atoms, ions, or molecules in a crystalline solid. Common cubic crystal structures include:
- Simple cubic (SC): Atoms are located only at the 8 corners of the cube.
- Body-centred cubic (BCC): Atoms are located at the 8 corners and one atom is at the center of the cube.
- Face-centred cubic (FCC): Atoms are located at the 8 corners and one atom is at the center of each of the 6 faces of the cube.

Solution: The provided diagram shows a unit cell with atoms at the corners and at the center of each face.

Step 1: Count the number of atoms at the corners.
There are 8 corners in a cube. Atoms are shown at each corner.

Step 2: Count the number of atoms at the faces.
There are 6 faces in a cube. Atoms are shown at the center of each face.

Step 3: Identify the crystal structure based on atom positions.
- Simple cubic: Atoms only at corners. This is not the case here.
- Body-centred cubic: Atoms at corners and one at the body center. There is no atom at the body center in the diagram.
- Face-centred cubic: Atoms at corners and at the center of each face. This matches the diagram. - Hexagonal close packed (HCP): This is not a cubic structure.

The diagram clearly shows atoms at all 8 corners and at the center of all 6 faces. This arrangement is characteristic of a face-centred cubic (FCC) lattice.

Final Answer: $\boxed{\text{Face-centred cubic}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 29

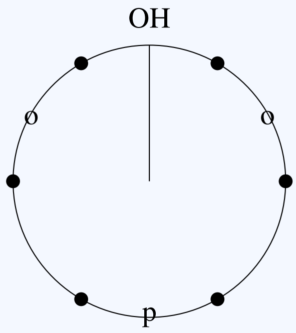
Q30.

Solution

Concept: Phenol (C_6H_5OH) is an aromatic alcohol. The hydroxyl group (-OH) attached to the benzene ring is activating and an ortho-, para- director due to resonance and inductive effects. This means that electrophilic substitution reactions on phenol occur preferentially at the ortho and para positions.

Bromine water (Br_2 in H_2O) is a highly reactive brominating agent. Due to the strong activating nature of the hydroxyl group in phenol, it can undergo rapid substitution at all available ortho and para positions, even without a Lewis acid catalyst.

Solution: Phenol has the structure:



The ortho positions are adjacent to the -OH group, and the para position is opposite to the -OH group.

When phenol reacts with bromine water (Br_2/H_2O), the hydroxyl group strongly activates the benzene ring towards electrophilic substitution at the ortho and para positions. All three of these positions are substituted by bromine.

The reaction is:

$$C_6H_5OH + 3Br_2 \xrightarrow{H_2O} C_6H_2(Br_3)OH + 3HBr$$

The product formed is 2,4,6-tribromophenol.

Final Answer: $\boxed{\text{2,4,6-tribromophenol}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 30

Q31.

Solution

Concept: The number of atoms in a given mass of an element can be calculated using Avogadro's number and the molar mass of the element.
Avogadro's number (N_A) is approximately 6.022×10^{23} particles (atoms, molecules, ions, etc.) per mole.
The molar mass of an element is numerically equal to its atomic mass in grams per mole.
The number of atoms = (Mass of the element / Molar mass of the element) × Avogadro's number.

Solution: We are given:
Mass of Helium (He) = 4 g

Step 1: Find the molar mass of Helium.
The atomic mass of Helium is approximately 4.00 g/mol.
So, the molar mass of He is 4.00 g/mol.

Step 2: Calculate the number of moles of Helium.
Number of moles = $\frac{\text{Mass}}{\text{Molar mass}} = \frac{4\text{ g}}{4.00\text{ g/mol}} = 1$ mole

Step 3: Calculate the number of atoms in 1 mole of Helium.
By definition, 1 mole of any element contains Avogadro's number of atoms.
Number of atoms = 1 mole $\times 6.022 \times 10^{23}$ atoms/mol
Number of atoms = 6.022×10^{23} atoms.

Final Answer: $\boxed{6.022 \times 10^{23}}$

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: The dipole moment (μ) is a measure of the polarity of a molecule. It is a vector quantity, resulting from the separation of positive and negative charges. For a molecule to have a net dipole moment, it must have polar bonds and an asymmetrical shape such that the bond dipoles do not cancel each other out.

- Symmetrical molecules with polar bonds usually have zero net dipole moment because the individual bond dipoles cancel each other.
- Asymmetrical molecules with polar bonds generally have a non-zero net dipole moment.

Solution: Let's analyze the structure and polarity of each molecule:

(A) CO_2 (Carbon dioxide): The molecule is linear ($O = C = O$). The C=O bonds are polar, with oxygen being more electronegative. However, due to the symmetrical linear arrangement, the bond dipoles are equal in magnitude and opposite in direction, so they cancel out. Net dipole moment = 0.

(B) BF_3 (Boron trifluoride): The molecule is trigonal planar and symmetrical. The B-F bonds are polar. Due to the symmetrical trigonal planar arrangement, the bond dipoles cancel each other out. Net dipole moment = 0.

(C) NH_3 (Ammonia): The molecule has a trigonal pyramidal shape. The N-H bonds are polar, with nitrogen being more electronegative. The molecule also has a lone pair of electrons on the nitrogen atom, which contributes to the overall dipole moment. Due to the asymmetrical shape and the presence of the lone pair, the bond dipoles do not cancel out, resulting in a significant net dipole moment. The dipole moment is directed from the hydrogen atoms towards the nitrogen atom and the lone pair.

(D) CCl_4 (Carbon tetrachloride): The molecule is tetrahedral and symmetrical. The C-Cl bonds are polar, with chlorine being more electronegative. However, due to the symmetrical tetrahedral arrangement, the bond dipoles cancel each other out.
Net dipole moment = 0.

Comparing the dipole moments, ammonia (NH_3) has a significant net dipole moment, while CO_2, BF_3, and CCl_4 have zero net dipole moments due to their symmetrical structures.

Final Answer:

$$\boxed{\mathrm{NH_3}}$$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 32

Q33.

Solution

Concept: Aldehydes can be reduced to primary alcohols, and ketones can be reduced to secondary alcohols. Strong reducing agents are capable of this transformation.

- PCC (Pyridinium Chlorochromate): This is a mild oxidizing agent used to oxidize primary alcohols to aldehydes and secondary alcohols to ketones. It does not reduce aldehydes to alcohols.
- $LiAlH_4$ (Lithium Aluminium Hydride): This is a strong reducing agent that can reduce aldehydes, ketones, carboxylic acids, esters, and amides. It reduces aldehydes to primary alcohols and ketones to secondary alcohols.
- Tollens reagent ($[Ag(NH_3)_2]^+$): This is a mild oxidizing agent used to test for aldehydes. It oxidizes aldehydes to carboxylic acids and is itself reduced to metallic silver. It does not reduce aldehydes to alcohols.
- Fehling solution: Similar to Tollens reagent, Fehling solution is used to test for aldehydes. It oxidizes aldehydes to carboxylic acids.

Solution: We need a reagent that converts aldehydes into primary alcohols.

Let's examine the function of each reagent:
- PCC: Oxidizing agent, not reducing. It converts primary alcohols to aldehydes.
- $LiAlH_4$: Strong reducing agent. It reduces aldehydes to primary alcohols. For example, if we have an aldehyde R-CHO, $LiAlH_4$ reduces it to R-CH_2OH (primary alcohol).
- Tollens reagent: Oxidizing agent for aldehydes.
- Fehling solution: Oxidizing agent for aldehydes.

Therefore, $LiAlH_4$ is the reagent that converts aldehydes into primary alcohols.

Final Answer:

$$\boxed{\text{LiAlH}_4}$$

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: Chemical bonds are formed by the overlap of atomic orbitals. There are two main types of covalent bonds:

1. Sigma (σ) bond: Formed by the axial (head-on) overlap of atomic orbitals. This overlap occurs along the internuclear axis. Sigma bonds are generally stronger than pi bonds.
2. Pi (π) bond: Formed by the lateral (sideways) overlap of atomic orbitals (typically p orbitals). This overlap occurs above and below the internuclear axis. Pi bonds are weaker than sigma bonds and are formed in addition to a sigma bond in double and triple bonds.

Solution: The given diagram illustrates the sideways overlap of two p orbitals. The overlapping region is located above and below the internuclear axis, forming a region of electron density that is perpendicular to the line joining the nuclei. This type of overlap is characteristic of a pi bond.

The diagram shows two p orbitals from different atoms overlapping side-by-side. This sideways overlap results in the formation of a pi bond. A sigma bond would be formed by the end-to-end overlap of orbitals. Ionic bonds involve the transfer of electrons, and coordinate bonds involve the sharing of an electron pair from one atom to another.

Final Answer: $\boxed{\text{Pi bond}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 34

Q35.

Solution

Concept: The Haber process is the industrial synthesis of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2). It is a reversible reaction that is exothermic and involves a decrease in the number of moles of gas. The reaction is:

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

A catalyst is used to increase the rate of the reaction without affecting the equilibrium position.

Solution: The Haber process typically uses an iron catalyst. The iron is often promoted with other substances like potassium oxide (K_2O) and aluminium oxide (Al_2O_3) to increase its efficiency. However, the fundamental catalyst is iron.

Let's look at the options:
- Ni (Nickel): Used as a catalyst in the hydrogenation of alkenes and alkynes.
- Pt (Platinum): Used as a catalyst in many reactions, including catalytic converters and hydrogenation.
- Fe (Iron): The primary catalyst used in the Haber process for ammonia synthesis.
- V_2O_5 (Vanadium pentoxide): Used as a catalyst in the contact process for the synthesis of sulfuric acid.

Therefore, iron is the catalyst used in the Haber process.

Final Answer: $\boxed{Fe}$

Answer: (C)

Go Back to Question 35

Q36.

Solution

Concept: Isoelectronic species are atoms or ions that have the same number of electrons. To determine if species are isoelectronic, we need to count the total number of electrons in each. The number of electrons in an atom is equal to its atomic number (Z). For an ion, we adjust the electron count based on the charge: for a cation with charge +n, we subtract n electrons; for an anion with charge -n, we add n electrons.
Neon (Ne) has an atomic number (Z) of 10. Therefore, a neutral neon atom has 10 electrons.

Solution: We need to find the species among the options that have 10 electrons.

(A) Na^+:
Sodium (Na) has Z = 11.
Na^+ has lost 1 electron, so it has $11 - 1 = 10$ electrons.

(B) F^-:
Fluorine (F) has Z = 9.
F^- has gained 1 electron, so it has $9 + 1 = 10$ electrons.

(C) Mg^{2+}:
Magnesium (Mg) has Z = 12.
Mg^{2+} has lost 2 electrons, so it has $12 - 2 = 10$ electrons.

(D) Cl^-:
Chlorine (Cl) has Z = 17.
Cl^- has gained 1 electron, so it has $17 + 1 = 18$ electrons.

Comparing the number of electrons:
- Ne: 10 electrons
- Na^+: 10 electrons
- F^-: 10 electrons
- Mg^{2+}: 10 electrons
- Cl^-: 18 electrons

Thus, Na^+, F^-, and Mg^{2+} are isoelectronic with Ne.

Final Answer:

$$\boxed{\text{Na}^+,\ \text{F}^-,\ \text{Mg}^{2+}}$$

Answer: (A,B,C)

Go Back to Question 36

Q37.

Solution

Concept: Hydrogen bonding is a special type of intermolecular attraction (or intramolecular, in some cases) that occurs when a hydrogen atom is bonded to a highly electronegative atom (like F, O, or N) and is attracted to another electronegative atom in a different molecule or in a different part of the same molecule. The electronegative atom must have a lone pair of electrons. The atoms involved are typically F, O, and N.

Solution: We need to identify which of the given species can form hydrogen bonds.

(A) HF (Hydrogen fluoride):
Hydrogen is bonded to Fluorine (F), which is highly electronegative and has lone pairs. The hydrogen atom in one HF molecule can form a hydrogen bond with the fluorine atom of another HF molecule. Thus, HF exhibits hydrogen bonding.

(B) NH_3 (Ammonia):
Hydrogen is bonded to Nitrogen (N), which is electronegative and has a lone pair. The hydrogen atom in one NH_3 molecule can form a hydrogen bond with the nitrogen atom of another NH_3 molecule. Thus, NH_3 exhibits hydrogen bonding.

(C) HCl (Hydrogen chloride):
Hydrogen is bonded to Chlorine (Cl). While chlorine is electronegative, it is less electronegative than F, O, or N. The electronegativity difference between H and Cl is not large enough, and the lone pairs on Cl are not sufficiently concentrated to form significant hydrogen bonds between HCl molecules. Hydrogen bonding is generally weak or absent in HCl.

(D) H_2O (Water):
Hydrogen is bonded to Oxygen (O), which is highly electronegative and has lone pairs. The hydrogen atoms in one H_2O molecule can form hydrogen bonds with the oxygen atom of another H_2O molecule. Thus, H_2O exhibits strong hydrogen bonding.

Therefore, HF, NH_3, and H_2O exhibit hydrogen bonding.

Final Answer: $\boxed{HF, NH_3, H_2O}$

Answer: (A,B,D)

Go Back to Question 37

Q38.

Solution

Concept: Electrolytes are substances that produce an electrically conducting solution when dissolved in a polar solvent, such as water. This is because they dissociate or ionize into ions.

- Strong electrolytes dissociate or ionize almost completely in water.
- Weak electrolytes dissociate or ionize only partially in water.
- Non-electrolytes do not dissociate or ionize in water and do not conduct electricity.

Common strong electrolytes include strong acids, strong bases, and most salts.

Solution: We need to identify the strong electrolytes from the given options.

(A) HCl (Hydrochloric acid): This is a strong acid. Strong acids dissociate almost completely in water:
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$
Thus, HCl is a strong electrolyte.

(B) NaOH (Sodium hydroxide): This is a strong base. Strong bases dissociate almost completely in water:
$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$
Thus, NaOH is a strong electrolyte.

(C) CH_3COOH (Acetic acid): This is a weak acid. Weak acids only partially dissociate in water:
$CH_3COOH(aq) \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$
Thus, acetic acid is a weak electrolyte.

(D) KCl (Potassium chloride): This is an ionic salt. Most ionic salts are strong electrolytes because they dissociate completely into ions when dissolved in water:
$KCl(aq) \rightarrow K^+(aq) + Cl^-(aq)$
Thus, KCl is a strong electrolyte.

Therefore, HCl, NaOH, and KCl are strong electrolytes.

Final Answer: $\boxed{\text{HCl, NaOH, KCl}}$

Answer: (A,B,D)

Go Back to Question 38

Q39.

Solution

Concept: A catalyst is a substance that alters the rate of a chemical reaction without itself being consumed in the process. Catalysts work by providing an alternative reaction pathway with a lower activation energy.

Key properties of catalysts:

- They increase the rate of a reaction.
- They do not change the equilibrium constant (K) of a reversible reaction. They help the reaction reach equilibrium faster by increasing both forward and reverse rates equally.
- They lower the activation energy (E_a) of the reaction.
- They are not consumed in the overall reaction, meaning they are regenerated at the end of the reaction cycle.

Solution: Let's evaluate each statement regarding catalysts:

(A) Catalysts increase reaction rate: This is a primary function of a catalyst. They speed up the reaction by providing a lower-energy pathway. Correct.

(B) Catalysts change equilibrium constant: This is incorrect. Catalysts affect the rate at which equilibrium is reached, but they do not shift the position of equilibrium. The equilibrium constant (K) is determined by thermodynamics (temperature) and is independent of the catalyst.

(C) Catalysts lower activation energy: This is correct. Catalysts provide an alternative reaction mechanism with a lower activation energy, allowing more reactant molecules to have sufficient energy to overcome the energy barrier and react.

(D) Catalysts remain chemically unchanged after reaction: This is correct. While catalysts participate in the reaction mechanism (forming intermediates), they are regenerated at the end of the catalytic cycle, so their net chemical composition remains unchanged.

Therefore, the correct statements are A, C, and D.

Final Answer:

$$\boxed{\begin{array}{c}\text{Catalysts increase reaction rate}\\ \text{Catalysts lower activation energy}\\ \text{Catalysts remain chemically unchanged after reaction}\end{array}}$$

Answer: (A,C,D)

Go Back to Question 39

Q40.

Solution

Concept: The aldol condensThe aldol condensation occurs between aldehydes or ketones in the presence of a base or acid catalyst to form a β-hydroxy aldehyde or ketone, which on dehydration gives an α, β-unsaturated carbonyl compound.

For aldol condensation to occur, the carbonyl compound must contain at least one α-hydrogen atom. These α-hydrogens are acidic and can be removed to form an enolate ion, which acts as the nucleophile in the reaction.

Solution: We need to check which of the given carbonyl compounds have α-hydrogens.

(A) Ethanal (CH_3CHO):
Structure: $CH_3 - CH = O$
The carbon adjacent to the carbonyl group (CH_3-) has 3 hydrogen atoms (α-hydrogens).
So, ethanal can undergo aldol condensation.

(B) Acetone (CH_3COCH_3):
Structure: $CH_3 - C(= O) - CH_3$
The carbons adjacent to the carbonyl group (both CH_3- groups) have α-hydrogens. Each CH_3 group has 3 α-hydrogens, for a total of 6 α-hydrogens. So, acetone can undergo aldol condensation.

(C) Benzaldehyde (C_6H_5CHO):
Structure: A benzene ring attached to a $-CHO$ group.
The carbon of the aldehyde group is directly attached to the phenyl ring. There are no hydrogen atoms on the carbon adjacent to the carbonyl group (the carbons of the benzene ring are not considered α-carbons in this context for aldol condensation). All hydrogens are on the phenyl ring, and the carbons of the phenyl ring attached to the carbonyl are also not adjacent to any α-hydrogens of the type required for enolate formation in aldol condensation. Benzaldehyde lacks α-hydrogens. Therefore, it cannot undergo aldol condensation (it can undergo the crossed aldol reaction as an electrophile, but not self-aldol condensation).

(D) Propanal (CH_3CH_2CHO):
Structure: $CH_3 - CH_2 - CH = O$
The carbon adjacent to the carbonyl group is the CH_2 group, which has 2 hydrogen atoms (α-hydrogens). So, propanal can undergo aldol condensation.

Thus, Ethanal, Acetone, and Propanal can undergo aldol condensation.

Final Answer: $\boxed{\text{Ethanal, Acetone, Propanal}}$

Answer: (A,B,D)

Go Back to Question 40

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	A	3	B	4	D	5	B
6	B	7	A	8	C	9	A	10	B
11	A	12	B	13	B	14	B	15	B
16	D	17	C	18	B	19	C	20	D
21	C	22	C	23	C	24	B	25	C
26	B	27	B	28	B	29	C	30	C
36	A,B,C	37	A,B,D	38	A,B,D	39	A,C,D	40	A,B,D