

## Round 1 - Level A

### INSTRUCTIONS TO CANDIDATES:

- (1). **Do not turn this page until you are told to do so**
- (2). This paper consists of **fifteen (15)** numbered pages
- (3). There are **sixty (60)** multiple choice questions. The duration of this exam in **1 hour and 30 minutes**.
- (4). Answer **all** questions. There is no negative marking.
- (5). In addition to this question paper, you should also have an answer sheet.
- (6). Each question has **four (4)** options - (A), (B), (C), (D). **Only one** is the correct answer.
- (7). On your answer sheet, completely shade your choice.
- (8). The use of non-programmable calculators is allowed.
- (9). A Periodic Table will not be provided.

1. In order to neutralize 50 mL of 1 M NaOH, which of the following acid solutions will be required in the highest volume?

- (A). 1 M  $H_2SO_4$
- (B). 1 M HCl
- (C). 1 M  $HNO_3$
- (D). 1 M  $CH_3COOH$

**Solution:**

- The weaker the acid the greater will be the volume required for neutralization.
- A, B, and C represent mineral acids that are described as strong acids.
- D is an organic acid, and is weak.

D is the correct answer.

2. Which of the following processes can be described as Osmosis?

- (A). Liquid bromine placed at the base of a measuring cylinder giving rise to brown vapours at the top
- (B). A crystal of iodine placed at the base of a measuring cylinder giving rise to brown vapours at the top
- (C). Your fingers becoming wrinkled after spending some time in the sea
- (D). A drop of ink placed on the middle of filter paper gradually spreading outward

**Solution:**

- Osmosis is the movement of solvent (**not** solute, **not** only water) particles across a semi-permeable membrane from a less concentrated solution to a more concentrated one.
- The solute particles do not move from one compartment to the next.
- This process continues until the solute concentration in both compartments is the same.
- A: does not involve a semi-permeable membrane, this is diffusion
- B: is also diffusion. Note that at atmospheric pressure, iodine undergoes sublimation, not vapourization like bromine.
- C: skin is a semi-permeable membrane. The concentration of salts (solute particles) in the sea is much higher than that in human cells. Water from within the cells moves out into the external environment creating the physical change observed. (Note that recent research has suggested that a different mechanism/explanation has been proposed for the phenomenon of wrinkling in non-salt water)
- D: This is movement along the stationary phase. This can be an example of paper chromatography: the components of the ink will be separated as a function of their different affinity for the paper.

**D** is the correct answer.

3. An antiproton has the same mass as a proton, but opposite charge. Which of the following describes the properties of an antiproton?

	Relative Charge	Relative Mass
(A).	+ 1	0
(B).	+ 1	1
(C).	- 1	1
(D).	- 1	0

**Solution:**

- A proton has a charge of + 1, and a relative mass of 1.
- A: This is an antielectron (positron)
- B: This is a proton
- C: This has a charge opposite to that of a proton, but the same mass
- D: This is an electron

**C** is the correct answer.

*Questions 4 - 7 refer to the following properties of different pure substances:*

	<i>State at RTP</i>	<i>Electrical Conductivity at RTP</i>
(A).	<i>Gas</i>	<i>No</i>
(B).	<i>Liquid</i>	<i>No</i>
(C).	<i>Solid</i>	<i>No</i>
(D).	<i>Solid</i>	<i>Yes</i>

*Which of the above properties most likely represents the following substances?*

**Solution:**

- Significant information about the structure and bonding within a substance can be gleaned from examining its physical properties
- Strength of intermolecular forces: solid >> liquid > gas
- To conduct an electric current requires the presence of species capable of carrying charge: free electrons, mobile ions

4.  $H_2S$

**A** is the correct answer

5.  $H_2O$

**B** is the correct answer

6.  $NaCl$

**C** is the correct answer

7. *Graphite*

**D** is the correct answer

8. *An atom, M, lost its 3 valence electrons to form an ion, N. Which of the following statements is true?*

(A). *N has more neutrons than M*

(B). *N has less neutrons than M*

(C). *N has more protons than M*

(D). *N is positively charged*

**Solution:**

- When an atom loses electrons (oxidation), the protons and neutrons are not affected.

- Electrons are negatively charged, and when a species has more protons than electrons, it is positively charged.

**D** is the correct answer.

9. *Diamond is best described as having this type of structure:*

(A). *Ionic*

(B). *Macromolecular*

(C). *Metallic*

(D). *Simple covalent*

**Solution:**

- Diamond is a covalent substance, but is the hardest naturally occurring substance. This is not representative of a substance with a simple covalent framework.
- Diamond does not conduct electricity in any state, nor does it dissolve in water. This not representative of an ionic or metallic structure.

**B** is the correct answer.

10. Consider the formula:  $\text{Na}_2\text{SO}_4 \cdot 5\text{H}_2\text{O}$  (s). This represents:

- (A). An aqueous solution of  $\text{Na}_2\text{SO}_4$
- (B). That there are 5 molecules of water of crystallization per molecule of  $\text{Na}_2\text{SO}_4$
- (C). A mixture of  $\text{Na}_2\text{SO}_4$  and ice
- (D). Molten  $\text{Na}_2\text{SO}_4$

**Solution:**

- A: This will be represented as  $\text{Na}_2\text{SO}_4$  (aq)
- B: Some ionic salts trap water in their lattice (often when recrystallized from aqueous solutions) and these are represented as: ionic salt . number of moles of water of crystallization
- C: This will be represented as  $\text{Na}_2\text{SO}_4$  (s) +  $\text{H}_2\text{O}$  (s)
- D: This will be represented as  $\text{Na}_2\text{SO}_4$  (l)

**B** is the correct answer.

11. You wish to accurately measure out 25.00 mL of hexane. Which apparatus will allow you to do so?

- (A). 50 mL pipette
- (B). 50 mL measuring cylinder
- (C). 50 mL burette
- (D). 50 mL beaker

**Solution:**

- Pay attention to the number of significant figures, which is representative of the accuracy of the measurement and hence the equipment used.
- A: A bulb pipette (assumed unless specified as a graduated pipette, which can measure different volumes accurately) cannot accurately measure any volume other than what it is specified for.
- B: A measuring cylinder is not suitable for accurate measurements

- C: A burette can discriminate between xx.00 and xx.50 mL.
- D: A beaker is even less accurate than a measuring cylinder

C is the correct answer.

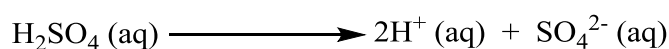
12. What is the pH of 0.01 M  $H_2SO_4$  (aq)?

- (A). 0.01
- (B). 1.7
- (C). 1.0
- (D). 2.0

**Solution:**

-  $pH = -\log[H^+]$  ( $\log A = \log_{10} A = \lg 10$ )

-  $H_2SO_4$  is (i) A diprotic acid and (ii) fully ionized in solution



1 (Answer C) mole  $H_2SO_4 = 2$  (Answer D) moles  $H^+$

0.01 (Answer A) moles = 0.02 moles  $H^+$

0.01 M  $H_2SO_4 = 0.02$  M  $H^+$

$[H^+] = 0.02$  M

$pH = -\log(0.02) = -(-1.7) = 1.7$

**B** is the correct answer.

13. When 1 mole of a strong acid is completely neutralized by 1 mole of a strong base, the theoretical amount of energy released is  $57.3 \text{ kJ mol}^{-1}$ . If 1 L of 1 M ethanoic acid is reacted with 1 L of 1 M NaOH (aq), what is a plausible enthalpy of neutralization?

- (A).  $0 \text{ kJ mol}^{-1}$
- (B).  $-57.3 \text{ kJ mol}^{-1}$
- (C).  $+57.3 \text{ kJ mol}^{-1}$
- (D).  $-54 \text{ kJ mol}^{-1}$

**Solution:**

- Ethanoic acid is a weak acid

- NaOH is a strong base

- The magnitude of the enthalpy of a neutralization reaction is a function of the extent of  $H^+/OH^-$  pairs available to freely undergo reaction. A weak acid will not contribute the same amount of

$H^+$  as a strong acid, of the same concentration, and therefore will be expected to release less energy.

- A negative enthalpy represents energy being released to the environment (exothermic)
- A: indicates no enthalpy change (and no neutralization reaction taking place)
- B: Same amount of energy released as a strong acid/strong base
- C: Endothermic process
- D: Less energy released than a strong acid/strong base

**D** is the correct answer.

14. *NaOH (aq) was reacted with HCl (aq) to produce a solution with a mass of 400 g. The temperature of the reaction increased by 3.5 °C. Given that the specific heat capacity of this solution = 4.18 J K<sup>-1</sup> g<sup>-1</sup>, how much heat was released by this reaction?*

- (A). 57.3 J
- (B). 5.80 kJ
- (C). 4.05 kJ
- (D). 4.18 kJ

**Solution:**

- For a given substance, the relationship between the heat absorbed/released and the temperature increase/decrease is given by the relationship:

$$Q = mc\Delta T$$

where Q = heat change; m = mass of substance; c = specific heat capacity of substance;  $\Delta T$  = change in temperature (1 °C = 1 K)

**Note** that the equation can also be represented as:  $Q = nc_n\Delta T$ , where n = no. of moles of the substance;  $c_n$  = molar heat capacity

- Always pay attention units and convert if necessary (e.g. kg or g)

$$\begin{aligned} - Q &= 400 \times 4.18 \times 3.5 \\ &= 5852 \end{aligned}$$

- Units Check:  $Q = g \times J K^{-1} g^{-1} \times K = J$

-  $Q = 5852 J = 5852 / 1000 kJ \approx 5.80 kJ$  (the more accurate approximation would be 5.9 kJ)

- A: correct value for **molar** heat of neutralization of HCl and NaOH, but incorrect unit

**B** is the correct answer.

15. What volume of carbon dioxide is produced at STP, when 1.0 mole of  $\text{CH}_4$  is completely combusted?

- (A).  $1.0 \text{ dm}^3$
- (B).  $2.0 \text{ dm}^3$
- (C).  $22.4 \text{ dm}^3$
- (D).  $24.0 \text{ dm}^3$

**Solution:**

- At STP, the volume of 1 mole of an ideal gas =  $22.4 \text{ dm}^3$
- Questions of this nature require the balanced equation for the reaction:  
$$\text{CH}_4 (\text{g}) + 2\text{O}_2 (\text{g}) \longrightarrow \text{CO}_2 (\text{g}) + 2\text{H}_2\text{O} (\text{g})$$
- 1 mole of  $\text{CH}_4$  = 1 mole of  $\text{CO}_2$
- 1 mole of  $\text{CO}_2$  =  $22.4 \text{ dm}^3$  at STP, assuming ideality
- D: the volume of an ideal gas at RTP

C is the correct answer.

16. If dry ice ( $\text{CO}_2(\text{s})$ ) is left at RTP, gaseous carbon dioxide will form. The process by which this occurs is:

- (A). Evaporation
- (B). Boiling
- (C). Condensation
- (D). Sublimation

**Solution:**

- The process described is a solid to gas transition
- A: liquid to gas transition
- B: liquid to gas transition at a phase change temperature (boiling point)
- C: gas to liquid transition

D is the correct answer.



17. Comparing distilled water to sea water:

- (A). Sea water and distilled water will have the same boiling point
- (B). Sea water will have a higher boiling point
- (C). Sea water will boil at  $< 100\text{ }^{\circ}\text{C}$
- (D). Sea water will have a higher freezing point

**Solution:**

- Sea water can be regarded as a solution of distilled water and dissolved salts and organic matter.
- Sea water can be regarded as impure distilled water.
- A: An impure substance will not have the same boiling point as a pure one
- B: Impurities increase the boiling point of a pure substance
- C: The boiling point of pure water is  $100\text{ }^{\circ}\text{C}$
- D: Impurities decrease the freezing point of a pure substance

**B** is the correct answer.

18. Both oxygen and sulphur are in the same Periodic group, with sulphur being the heavier atom.

At RTP,  $\text{H}_2\text{O}$  is a liquid, but  $\text{H}_2\text{S}$  is a gas. What is the reason for this?

- (A).  $\text{H}_2\text{S}$  is heavier
- (B).  $\text{H}_2\text{O}$  is lighter
- (C).  $\text{H}_2\text{O}$  is ionic
- (D).  $\text{H}_2\text{O}$  has extensive hydrogen bonding

**Solution:**

- Difference in physical properties such as state of existence at a given temperature and pressure, is a function of the intermolecular forces of attraction. The greater these forces, the greater the order of particles (solid  $\gg$  liquid  $>$  gas)
- A and B: Both of these statements are correct. Neither is the correct reason.
- C:  $\text{H}_2\text{O}$  is a simple covalent molecule
- D: Oxygen is the 2nd most electronegative element, and the H-O system facilitates H-bonding.

**D** is the correct answer.

19. What is the best technique to separate a homogeneous mixture of the following liquids:

I. water

II. methanol: boiling point = 65 °C, density = 0.792 gcm<sup>-3</sup>

III. propan-1-ol: boiling point = 98 °C, density = 0.803 gcm<sup>-3</sup>

(A). Simple distillation

(B). Filtration

(C). Use of a Separatory Funnel

(D). Fractional Distillation

**Solution:**

- A: I and III have very similar boiling points and hence simple distillation will not be effective
- B: Separation of a solid from a liquid
- C: Separation of immiscible liquids
- D: Separation of a mixture of liquids through repeated boiling/condensation cycles e.g. crude oil distillation.

**D** is the correct answer.

20. Bronze is best described as what type of mixture?

(A). Solid in liquid solution

(B). Liquid in solid solution

(C). Solid and solid

(D). Liquid and liquid

**Solution:**

- Bronze is a mixture of copper and tin, and sometimes minor amounts of other elements.
- The components of bronze are solids at room temperature

**C** is the correct answer.

21. Consider 1 g of  $\text{Br}_2$  in different states of matter. Which particles have the greatest kinetic energy?

- (A). *solid* > *liquid* > *gas*
- (B). *liquid* > *solid* > *gas*
- (C). *gas* = *liquid* > *solid*
- (D). *gas* > *liquid* > *solid*

**Solution:**

- The kinetic energy (K.E.) of a particle is the energy it possesses due to its motion.
- $\text{K.E.} = \frac{1}{2}mv^2$ , where  $m$  = mass;  $v$  = velocity
- The greater the speed of the particles, the greater the K.E.
- Order of freedom of motion: solid  $\ll$  liquid < gas;  
therefore speed of particles: solid  $\ll$  liquid < gas

**D** is the correct answer.

22. Arrange the following elements in order of decreasing reactivity with water:

- (A).  $K > Na > S > Li$
- (B).  $K > Na > Li > S$
- (C).  $S > Na > K > Li$
- (D).  $Na > K > Li > S$

**Solution:**

- Each option has three Group I elements: Li, Na, K; and one Group VI element: S
- The metallic elements show trends of reactivity as follows: Group I > Group 2 > Group 3; reactivity increases down the group. Reaction with water generates a metal hydroxide (alkaline solution) and liberates  $\text{H}_2$  (g)
- Typically, the non-metals do not react with water; except the Halogens (Group VII):  $\text{Cl}_2$ ,  $\text{Br}_2$  and  $\text{I}_2$  react with water to give solutions of varying bleaching power ( $\text{Cl}_2 > \text{Br}_2 > \text{I}_2$ )

**B** is the correct answer.

23.  $\text{CaSO}_4$  is a salt that is sparingly soluble in water at room temperature. What is the best method for purifying  $\text{CaSO}_4$  from a mixture containing solid impurities that are insoluble in boiling water?

- (A). Fractional distillation
- (B). Recrystallization
- (C). Simple distillation
- (D). Sublimation

**Solution:**

- A: Separation of a complex mixture of liquids
- B: Separation of a solid from impurities, utilizing the fact that solubility of a substance increases with increasing temperature
- C: Separation of a few liquids with significant differences in boiling points; and which do not form azeotropes
- D: Used to purify a solid through the application of a vacuum, causing the substance to sublime and then deposit on a cold surface. Requires specialized equipment.

**B** is the correct answer.

24. Arrange the following compounds in terms of increasing intermolecular forces of attraction:

- (A).  $\text{H}_2 < \text{Cl}_2 < \text{I}_2 < \text{Br}_2$
- (B).  $\text{H}_2 < \text{Cl}_2 < \text{Br}_2 < \text{I}_2$
- (C).  $\text{H}_2 < \text{I}_2 < \text{Cl}_2 < \text{Br}_2$
- (D).  $\text{Cl}_2 < \text{H}_2 < \text{Br}_2 < \text{I}_2$

**Solution:**

- The physical state of the substance gives an indication of the relative strength of the prevalent intermolecular forces of attraction
- Examining the structure of the molecule can assist in identification of the type of intermolecular forces that exist
- $\text{H}_2$ : Predominantly van der Waals forces
- Halogens: Temporary dipoles exist
- At RTP:  $\text{Cl}_2$  = gas;  $\text{Br}_2$  = liquid;  $\text{I}_2$  = solid

**B** is the correct answer.

25. Which of the following pairs of substances are allotropes?

- (A). Chlorine-35 and Chlorine-37
- (B). Na and Li
- (C). Red phosphorus and white phosphorus
- (D). Na and Mg

**Solution:**

- Allotropes are the different forms of the same element, in a given physical state
- A: Isotopes
- B: Elements of the same Group
- C: P<sub>red</sub> and P<sub>white</sub> are both solids at RTP.
- D: Elements of the same Period

C is the correct answer.

26. What volume does 16 g of SO<sub>2</sub> occupy at RTP? Assume that SO<sub>2</sub> is an ideal gas.

$$A_r: S = 32; O = 16$$

- (A). 6.0 dm<sup>3</sup>
- (B). 12.0 dm<sup>3</sup>
- (C). 24.0 dm<sup>3</sup>
- (D). 48.0 dm<sup>3</sup>

**Solution:**

- At RTP, the volume of 1 mole of an ideal gas = 24.0 dm<sup>3</sup>
- M<sub>r</sub> of SO<sub>2</sub> = (32 x 1) + (16 x 2) = 64
- 64 g SO<sub>2</sub> = 1 mole SO<sub>2</sub>
- 16 g SO<sub>2</sub> = 0.25 mole SO<sub>2</sub>
- 1 mole SO<sub>2</sub> = 24.0 dm<sup>3</sup> at RTP
- 0.25 mole SO<sub>2</sub> = 6.0 dm<sup>3</sup>

A is the correct answer.

27. 0.5 g of NaOH were dissolved in 100 mL of distilled water. What is the concentration of this solution?

$$A_r: Na = 23; O = 16; H = 1$$

- (A). 0.5 M
- (B). 0.0125 M
- (C). 0.125 M
- (D). 40.0 M

**Solution:**

- $M_r$  of NaOH =  $(23 \times 1) + (16 \times 1) + (1 \times 1) = 40$
- 40 g NaOH = 1 mole NaOH
- 0.5 g NaOH = 0.0125 mole NaOH
- 100 mL water = 0.5 g NaOH = 0.0125 mole NaOH
- 1000 mL water = 0.125 mole NaOH
- Concentration of this solution =  $0.125 \text{ mol dm}^{-3}$

C is the correct answer.

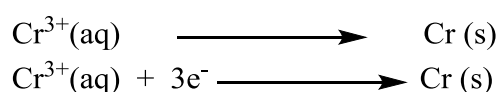
28. A  $Cr^{3+}$  solution is electrolyzed, using a current of 7.60 A. What mass of Cr (s) is formed after 2 days?

$$F = 96,500 \text{ C mol}^{-1}; \quad A_r: Cr = 52$$

- (A). 52 g
- (B). 236 g
- (C). 7.6 g
- (D). 2 g

**Solution:**

- Write the half-cell equation showing the number of electrons gained or lost to form the atom or ion:



- $Q = It$ ; where Q = charge delivered in Coulombs, I = current in Ampere, t = time in s
  - 2 days =  $2 \times 24 \text{ hours} = 2 \times 24 \times 60 \text{ minutes} = 2 \times 24 \times 60 \times 60 \text{ s} = 172,800 \text{ s}$
  - $Q = 7.60 \text{ A} \times 172,800 \text{ s} = 1,313,280 \text{ C}$
  - $A_r$  of Cr = 52, therefore 1 mole of Cr = 52 g
  - $F = 96,500 \text{ C mol}^{-1}$ , therefore 1 mole of  $e^- = 96,500 \text{ C}$
  - From the half equation:
- 3 mole  $e^- = 1 \text{ mole Cr}$

$$3 \times 96,500 \text{ C} = 52 \text{ g Cr}$$

$$289,500 \text{ C} = 52 \text{ g Cr}$$

$$1,313,280 \text{ C} = 236 \text{ g Cr}$$

**B** is the correct answer.

29. How many molecules of  $\text{CO}_2$  are present in 22 g of  $\text{CO}_2$ ?

$$A_r: \text{C} = 12; \text{O} = 16$$

(A). 22

(B).  $6.023 \times 10^{23}$

(C).  $3.01 \times 10^{23}$

(D). 44

**Solution:**

$$\text{- } M_r \text{ of } \text{CO}_2 = (12 \times 1) + (16 \times 2) = 44$$

$$\text{- } 44 \text{ g } \text{CO}_2 = 1 \text{ mole } \text{CO}_2$$

$$\text{- } 22 \text{ g } \text{CO}_2 = 0.5 \text{ moles } \text{CO}_2$$

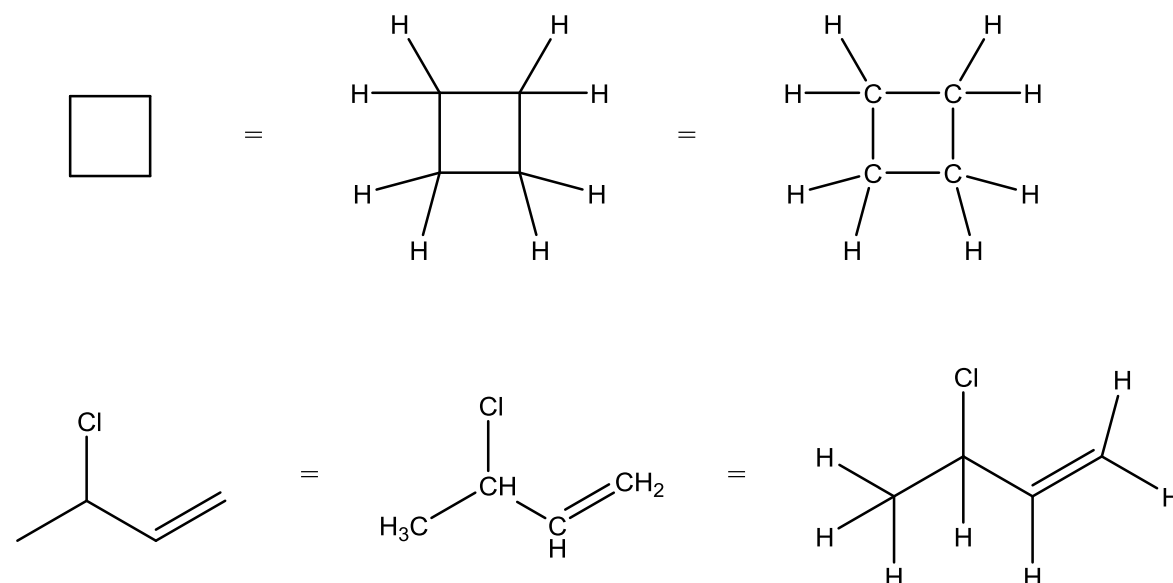
$$\begin{aligned} \text{- } 1 \text{ mole } \text{CO}_2 &= N_A \text{ (Avogadro's number) molecules } \text{CO}_2 \\ &= 6.023 \times 10^{23} \text{ molecules } \text{CO}_2 \end{aligned}$$

$$\text{- } 0.5 \text{ moles } \text{CO}_2 = 3.01 \times 10^{23} \text{ molecules } \text{CO}_2$$

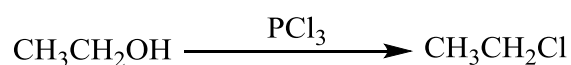
**C** is the correct answer.

**Organic Chemistry is the Chemistry of Functional Groups. It is not the chemistry of memorizing the reactions of individual molecules (of which the number is infinite); but rather understanding the reactions of classes of molecules. Some useful guidelines:**

(i) There are different ways of representing organic structures:

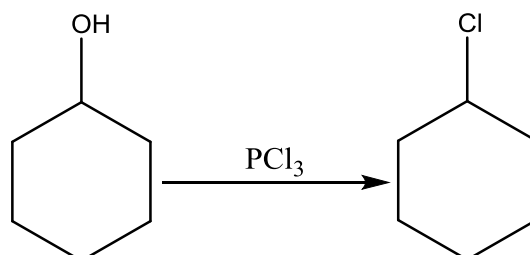


(ii) Focus on the functional group (s), not the rest of the molecule when considering simple transformations. For example: Given that the following transformation occurs:



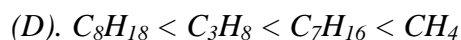
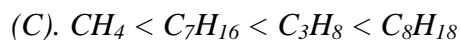
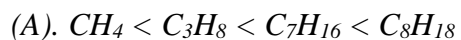
What would happen if cyclohexanol was reacted with  $\text{PCl}_3$ ?

- In the above equation, the alcohol group is being replaced by a chlorine; the remainder of the molecule (hydrocarbon portion/alkyl chain) is unaffected. It is reasonable then to predict that the following will be the outcome with cyclohexanol:





30. Considering the homologous series of alkanes, arrange the following compounds in order of increasing boiling point:



**Solution:**

- For a homologous series, as molecular size (molecular formula) increases, the intermolecular forces of attraction will increase. This will therefore mean that more energy is required to separate individual molecules from each other in a given phase, and hence boiling point (among other properties) increases.

- Arrange the compounds in terms of increasing molecular size.

A is the correct answer.

31. How many structural isomers exist, that possess the formula:  $C_4H_{10}$ :

(A). 1

(B). 2

(C). 3

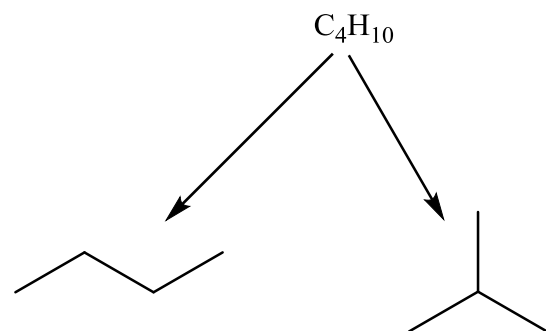
(D). 4

**Solution:**

- Structural isomerism is distinct from stereoisomerism.

- One approach is to draw the unbranched compound represented by the formula, and then use that as the template to draw branched isomers

- **Also consider if cyclic structural isomers can exist**



B is the correct answer.

32. Addition of a few drops of conc.  $H_2SO_4$  to the reaction between ethanol and ethanoic acid increases the rate of product formation. What is the role of the  $H_2SO_4$  in this reaction?

- (A). Oxidizing agent
- (B). Reducing agent
- (C). Inhibitor
- (D). Promoter

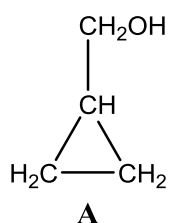
**Solution:**

- The  $H_2SO_4$  is not altering the identity of the products formed, and is therefore not a reactant, eliminating options (A) and (B).
- The  $H_2SO_4$  is chemically unchanged at the end of the reaction, is altering the rate of the reaction, and is therefore a catalyst.
- The rate of this reaction is increased, and the specific type of catalytic activity is therefore promotion.

**D** is the correct answer.

Questions 33 - 36 refer to the statement below:

$KMnO_4/H^+$  is slowly added to compound **A**:



33. What is the oxidation number of the manganese in  $KMnO_4$ ?

- (A). 0
- (B). + 2
- (C). - 2
- (D). + 7

**Solution:**

- The oxidation numbers of: K = +1; O = -2

-  $\text{KMnO}_4$  is a neutral compound, and therefore the sum of all charges of individual atoms present in its structure must be equal to 0:

$$(1 \times \text{K}) + (1 \times \text{Mn}) + (4 \times \text{O}) = 0;$$

$$(1 \times +1) + (1 \times \text{Mn}) + (4 \times -2) = 0$$

$$\text{Mn} = +7$$

**D** is the correct answer.

34. What will be observed when the  $\text{KMnO}_4/\text{H}^+$  mixes with **A**?

(A). The purple colour disappears

(B). No visible reaction

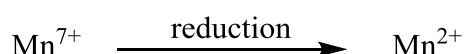
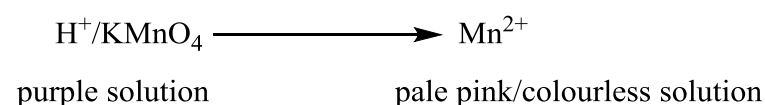
(C). The orange colour disappears

(D). A green solution is formed

**Solution:**

-  $\text{KMnO}_4/\text{H}^+$  is an oxidizing agent, and compound **A** is capable of undergoing oxidation (primary alcohol to carboxylic acid)

- The oxidizing agent will undergo reduction:



**A** is the correct answer.

35. What is the identity of the manganese species that is formed?

(A).  $\text{Mn}^{2+}$

(B).  $\text{Mn}^{7+}$

(C).  $\text{Mn}^{4+}$

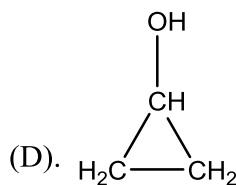
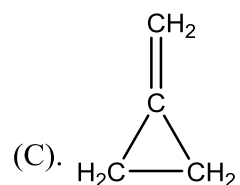
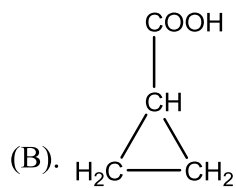
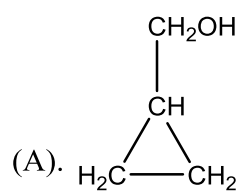
(D).  $\text{Mn}$

**Solution:**

- See explanation in Question 34.

**A** is the correct answer.

36. What is the structure of the organic product that is formed?

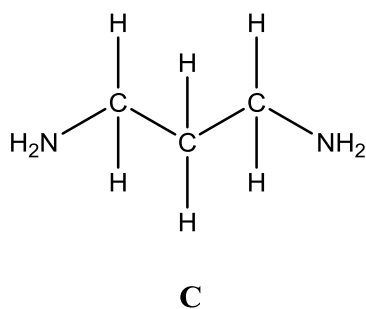
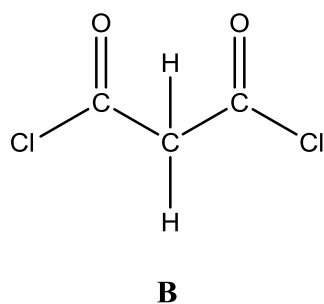


**Solution:**

- See explanation in Question 34.
- A: No reaction
- B: Oxidation
- C: Dehydration
- D: Chain shortening by 1 Carbon

**B** is the correct answer.

37. What type of polymer is formed when **B** and **C** are reacted with each other?

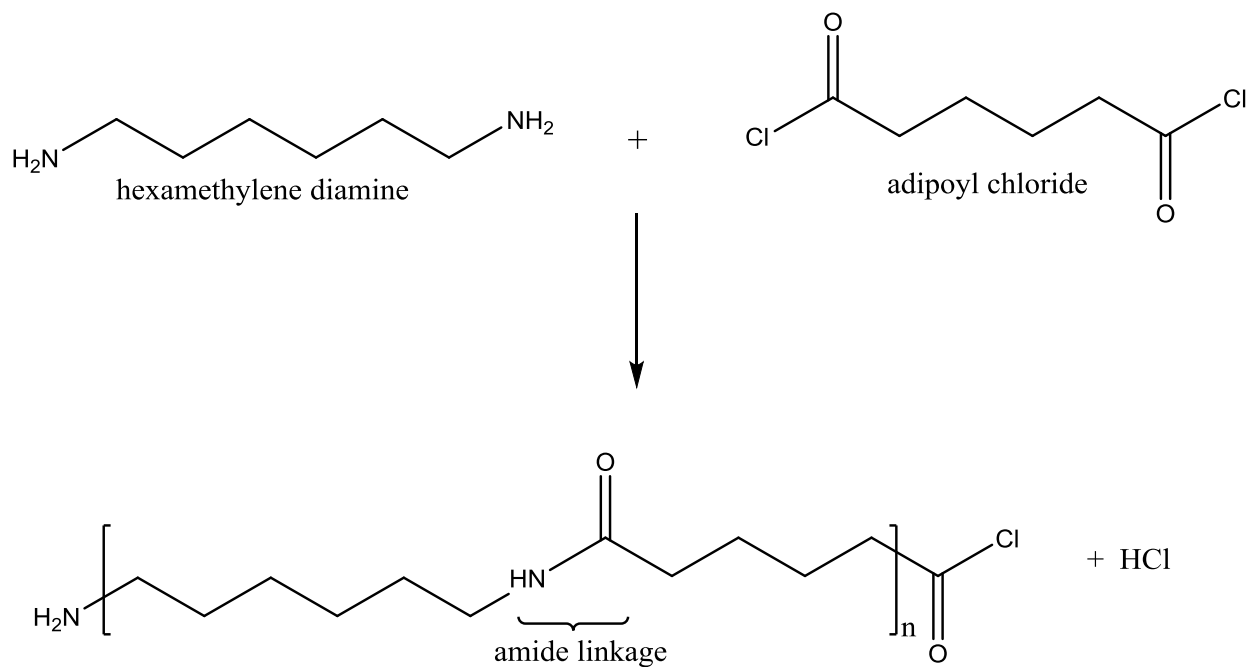


- (A). Polyester
- (B). Polysaccharide
- (C). Polyalkene
- (D). Polyamide

**Solution:**

- An amine and an acid chloride will react to give an amide
- **B** is a diacid chloride and **C** is a diamine

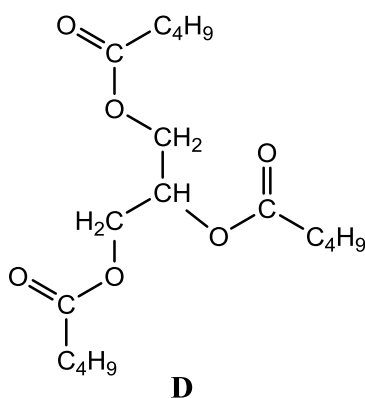
- A simple example of the reaction of a diacid and a diamine is that involved in the formation of Nylon-6,6, a polyamide:



- Any diacid/diamine pair will be expected to react in a similar manner

**D** is the correct answer.

38. Compound **D** shown below, undergoes saponification with  $\text{NaOH} (\text{aq}) / \Delta$ .



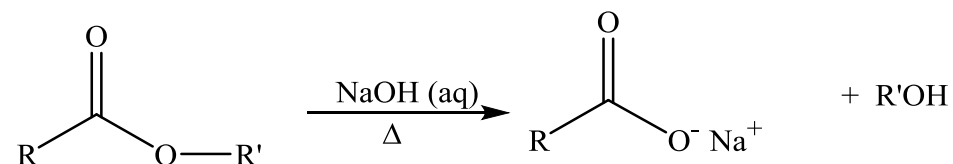
What are the product(s) of this reaction?

- (A).  $\text{C}_4\text{H}_9\text{COOH}$  and  $\text{C}_3\text{H}_8\text{O}_3$
- (B).  $\text{C}_4\text{H}_9\text{COO}^-\text{Na}^+$  and  $\text{C}_3\text{H}_8\text{O}_3$
- (C).  $\text{C}_4\text{H}_9\text{OH}$  and  $\text{C}_3\text{H}_8\text{O}_3$
- (D).  $\text{C}_4\text{H}_9$  and  $\text{C}_3\text{H}_8\text{O}_3$

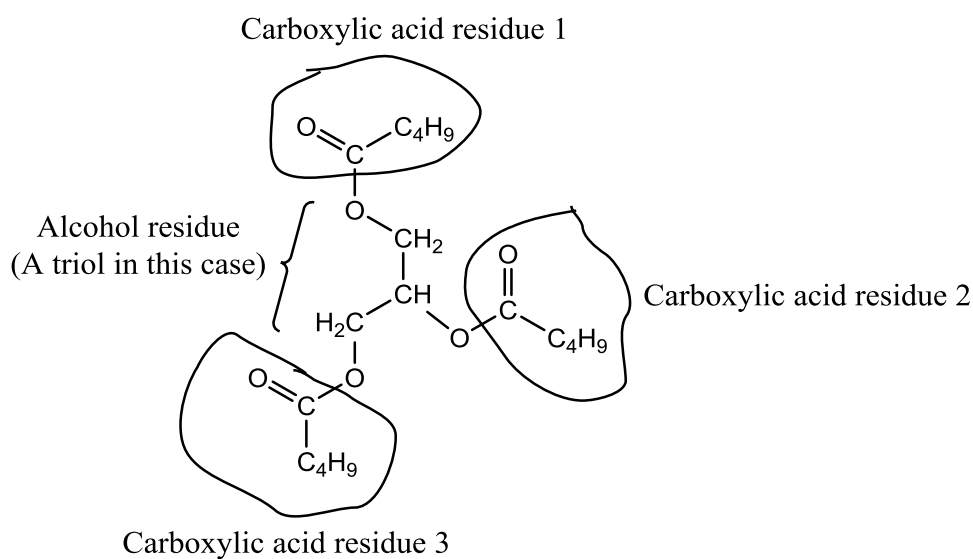
**Solution:**

- Saponification is the process by which triglycerides (fats/oils) are converted into a soap (carboxylic acid salt) and alcohol, under the action of a base.

- At its simplest, it can be regarded as base-mediated hydrolysis of an ester linkage:



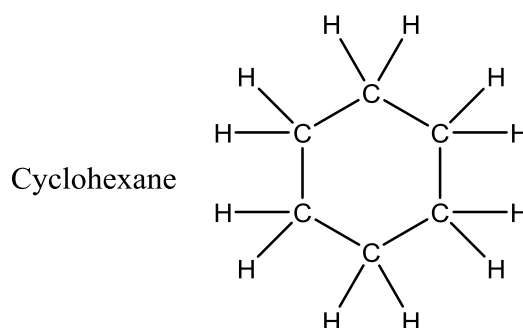
- There are three equivalent ester linkages present in **D**:



- A: Carboxylic acid and alcohol
- B: Salt of carboxylic acid and alcohol
- C: Two different alcohols
- D: Alkyl residue and alcohol

**B** is the correct answer.

39. Consider a beaker in a dark room, to which liquid bromine and excess cyclohexane have been mixed at RT.



Which of the following statements is true?

- (A). If the mixture is exposed to sunlight, it will become colourless  
 (B). The mixture is colourless  
 (C). If the mixture is exposed to sunlight, no visible reaction will be observed  
 (D). The mixture alternates in colour between blue and colourless, over time

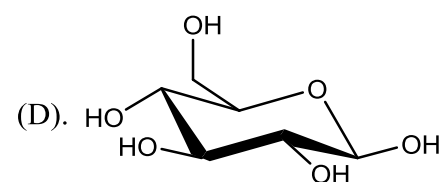
**Solution:**

- Cyclohexane is an alkane. Alkanes require a source of energy (heat or uv light) to react with (and decolourize) halogens. At RT and in the dark, no reaction will occur and the orange/brown colour of bromine will persist.

A is the correct answer.

40. Which of the following compounds, when fermented, will yield ethanol?

- (A).  $C_3H_7OH$   
 (B).  $C_2H_6$   
 (C).  $CH_3COOH$



**Solution:**

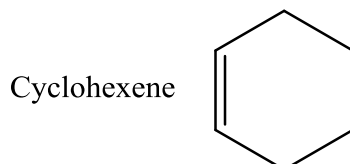
- Fermentation is the anaerobic reaction (absence of oxygen) of carbohydrates (glucose, fructose, sucrose) to yield ethanol and carbon dioxide.

- A: Propan-1-ol  
 - B: Ethane  
 - C: Ethanoic acid  
 - D: Glucose

- Note that even if the identity of the structure represented in choice (D) was unknown, by a process of elimination, options (A) - (C) are invalid.

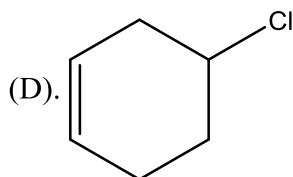
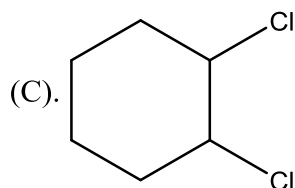
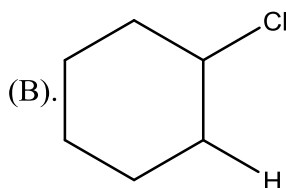
**D** is the correct answer.

41. Cyclohexene is reacted with chlorine gas at RT in the dark.



Which of the following are possible products, if any?

(A). No reaction



**Solution:**

- Alkenes possess a double bond, which is comprised of a  $\pi$  bond and a  $\sigma$  (single) bond. A  $\pi$  bond is much weaker, and therefore more reactive, than a  $\sigma$  bond.

- Via their  $\pi$  bond, alkenes can therefore undergo reaction with halogens to yield a dihalide.

- A: No reaction

- B: Addition of hydrogen chloride

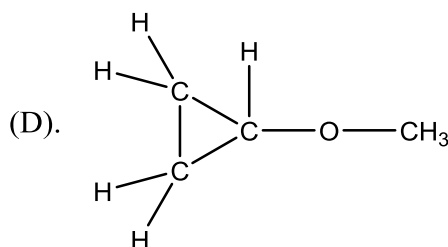
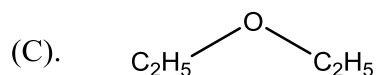
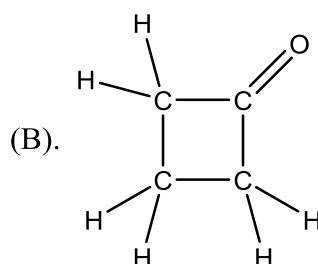
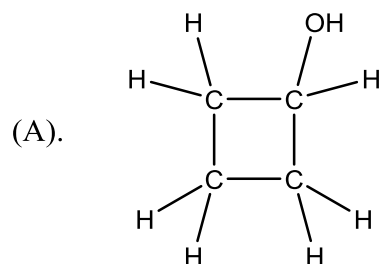
- C: Addition of chlorine

- D: Substitution of a chlorine atom for a hydrogen atom

**C** is the correct answer.



42. An organic compound, **J**, has four carbons, and shows mild effervescence with sodium metal. Which of the following is a possible structure of **J**?



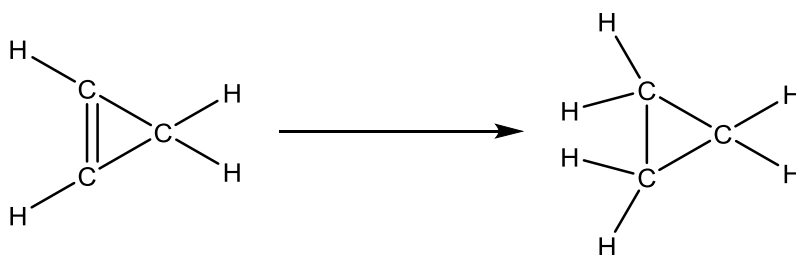
**Solution:**

- Among others, sodium metal undergoes reaction with alcohols and carboxylic acids, to yield hydrogen gas and the corresponding sodium salt.

- A: Alcohol
- B: Carbonyl
- C: Ether
- D: Ether

**A** is the correct answer.

43. You wish to perform the following reaction:



Which of the following will you employ?

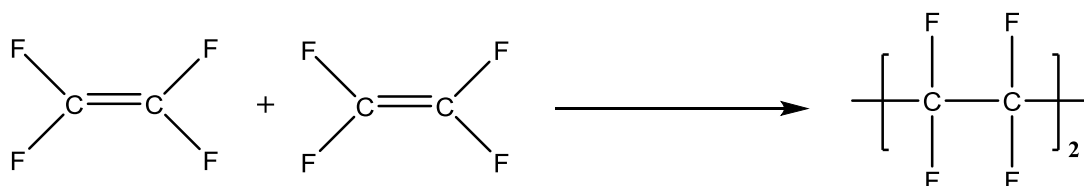
- (A).  $H_2 / Ni$
- (B).  $H_2O / \Delta$
- (C).  $H_2SO_4 / \Delta$
- (D).  $HCl / \Delta$

**Solution:**

- In this reaction, a double bond is being removed in the reactant, and a hydrogen atom is added to each carbon (of the previous double bond).
- This is hydrogenation of an alkene, requiring hydrogen gas and a suitable catalyst

A is the correct answer.

44. Consider the following reaction that leads to the production of the polymer PTFE (polytetrafluoroethylene), that is used in non-stick coatings:



What type of reaction best describes this process?

- (A). Addition
- (B). Substitution
- (C). Condensation
- (D). Fluorination

**Solution:**

In the context of a polymerization process:

- A: Reaction of two alkenes to give a dimer (longer chain alkane)
- B: Replacement of one atom or group of atoms, by another
- C: Two monomers reacting to form a dimer and a small byproduct
- D: Incorporation of fluorine

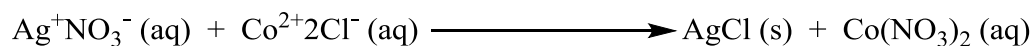
A is the correct answer.

45.  $\text{AgNO}_3$  (aq) was mixed with  $\text{CoCl}_2$  (aq). What would be observed?

- (A). A white precipitate is formed
- (B). A colourless solution is formed
- (C). A yellow precipitate is formed
- (D). A yellow solution is formed

**Solution:**

- When two aqueous solutions of different salts are mixed, ion exchange can occur:



- All common nitrates are soluble in water
- AgCl is a white solid

**A** is the correct answer.

46. *KI (aq) is added to a solution of an unknown salt, and a yellow precipitate is formed. Which of the following ions is most likely present?*

- (A).  $\text{Na}^+$
- (B).  $\text{Br}^-$
- (C).  $\text{Cl}^-$
- (D).  $\text{Pb}^{2+}$

**Solution:**

- All common salts of  $\text{Na}^+$  and  $\text{K}^+$  are soluble in water.
- A: NaI will form
- B: KBr will form
- C: KCl will form
- D:  $\text{PbI}_2$  will form
- $\text{PbI}_2$  is a yellow solid

**D** is the correct answer.

47. *Which of the following compounds is expected to be insoluble at RT in water?*

- (A). *Potassium chloride*
- (B). *Strontium nitrate*
- (C). *Lead nitrate*
- (D). *Lead carbonate*

**Solution:**

- All common salts of  $\text{Na}^+$  and  $\text{K}^+$  are soluble in water at RT
- All simple nitrates are soluble in water at RT

**D** is the correct answer.

48. Which of the following gases will turn moist red litmus paper blue?

- (A).  $HCl$
- (B).  $SO_2$
- (C).  $NH_3$
- (D).  $H_2S$

**Solution:**

- Moist red litmus will be turned blue by an alkaline substance
- A: Acidic
- B: Acidic
- C: Basic
- D: Acidic

C is the correct answer.

49. A simple metal carbonate,  $MCO_3$ , is heated until it decomposes, Which of the following is likely to be observed?

- (A). Water vapour is produced
- (B). No gas is evolved
- (C). A yellow-green gas is produced
- (D). A colourless gas which turns lime water milky, is produced

**Solution:**

- Metal carbonates undergo thermal decomposition as follows:
- $$MCO_3 (s) \longrightarrow MO (s) + CO_2 (g)$$
- $CO_2 (g)$  is colourless and turns lime water milky

D is the correct answer.

50. Which of the following oxides is most likely to chemically react with 1 M  $HCl (aq)$ ?

- (A).  $Na_2O$
- (B).  $SO_2$
- (C).  $CO_2$
- (D).  $CO$

**Solution:**

- HCl (aq) is an acidic solution and will undergo reaction with those oxides that are basic in nature, to yield a salt and water.
- Basic oxides typically are formed with metals, while acidic oxides tend to be formed with the non-metals.
- A: Basic
- B: Acidic
- C: Weakly acidic
- D: Neutral

A is the correct answer.

51. Which of the following oxides is most likely to chemically react with 1 M NaOH (aq)?

- (A).  $K_2O$
- (B).  $SO_2$
- (C).  $CaO$
- (D).  $BaO$

**Solution:**

- NaOH (aq) is an acidic solution and will undergo reaction with those oxides that are acidic in nature, to yield a salt and water.
- Basic oxides typically are formed with metals, while acidic oxides tend to be formed with the non-metals.
- A: Basic
- B: Acidic
- C: Basic
- D: Basic

B is the correct answer.

52. Acid rain is likely to cause the most damage to buildings made from this substance:

- (A).  $CaCO_3$
- (B).  $CaSO_4$
- (C). Clay
- (D). Concrete

**Solution:**

- Acidic substances will react with basic oxides (to yield a salt and water), carbonates (to yield a salt, carbon dioxide and water), and metals (to yield a salt and hydrogen gas)

A is the correct answer.

53. Hydrated copper sulphate, when heated, changes colour from blue to white. Why does this occur?

(A). Loss of  $H_2O$

(B). Loss of  $SO_2$

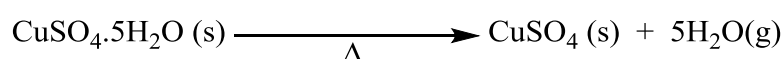
(C). Loss of  $SO_2$  and  $H_2O$

(D). Loss of  $H_2O$  and  $CO_2$

**Solution:**

- Heating a hydrated salt will drive off its water of crystallization, in a physical process; which may result in a colour change.

- The transformation taking place is:



A is the correct answer.

54. On heating,  $Cu(NO_3)_2$  yields a gas and a black solid. What is the identity of the gas?

(A).  $CO_2 (g)$

(B).  $O_2 (g)$

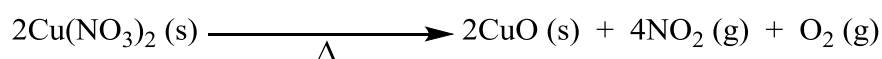
(C).  $NO_2 (g)$

(D).  $NH_3 (g)$

**Solution:**

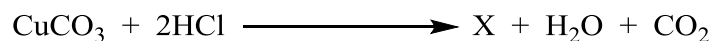
- Heating nitrates yields an oxide, nitrogen dioxide, and oxygen

- The transformation taking place here is:



Either B or C is the correct answer.

55. Copper carbonate reacts with hydrochloric acid according to the following balanced equation:



What is the identity of X in the above equation?

- (A).  $\text{CuCl}_2$
- (B).  $\text{Cu}_2\text{Cl}$
- (C).  $2\text{CuCl}$
- (D).  $\text{CuCl}$

**Solution:**

- Metallic oxides are typically basic, and will undergo reaction with acid to yield a salt, water, and carbon dioxide
- No change in oxidation state of the metal is expected
- In  $\text{CuCO}_3$ , the oxidation state of Cu = +2
- A:  $\text{Cu}^{2+}$
- B:  $\text{Cu}^{0.5+}$  (cannot exist)
- C:  $\text{Cu}^{1+}$
- D:  $\text{Cu}^{1+}$

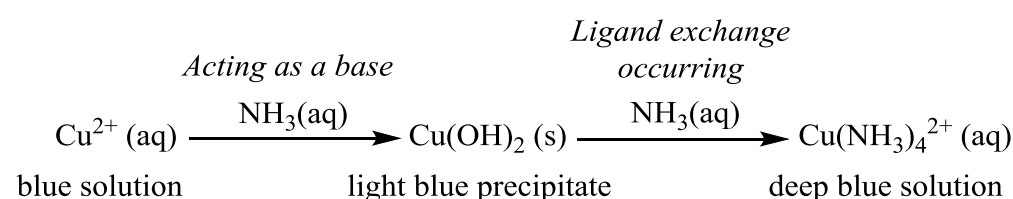
A is the correct answer.

56. What would be observed if  $\text{NH}_3(\text{aq})$  is slowly added to an aqueous solution of  $\text{CuSO}_4$ ?

- (A). The blue solution becomes lighter in colour
- (B). The blue solution becomes colourless
- (C). A pale blue precipitate is initially formed, which dissolves to form a deep blue solution upon the further addition of  $\text{NH}_3(\text{aq})$
- (D). A pale blue precipitate is formed which is insoluble in excess  $\text{NH}_3(\text{aq})$

**Solution:**

- The simplified transformation taking place is:



C is the correct answer.

57. An orange solution was made by dissolving a metal salt in water. This solution gave a blood red colouration with potassium thiocyanate (KSCN). What is the most likely identity of the cation present:

- (A).  $Fe^{3+}$
- (B).  $Fe^{2+}$
- (C).  $Ca^{2+}$
- (D).  $Na^{+}$

**Solution:**

- Formation of a blood red solution with  $SCN^{-}$  (aq) is a confirmatory test for the presence of  $Fe^{3+}$



A is the correct answer.

58. Arrange the following elements in terms of increasing metallic character:

- (A).  $Na < Mg < P < Ar$
- (B).  $Mg < Na < P < Ar$
- (C).  $Ar < P < Mg < Na$
- (D).  $Ar < P < Na < Mg$

**Solution:**

- Metallic character increases down a group, and from right to left on the Periodic Table

C is the correct answer.

59. An element, Y, has an electronic configuration: 2,8,8,1. Which of the following is likely to describe its properties?

- I. Reacts violently with water
- II. Can be cut with a knife
- III. Conducts electricity
- IV. Volatile liquid at RT

- (A). I only
- (B). IV only
- (C). I and IV only
- (D). I, II and III only



**Solution:**

- With one valence electron, element Y is a Group I element (alkali metal)
- (I), (II), and (III) are properties of Group I elements
- (IV) is not a characteristic of the Group I elements

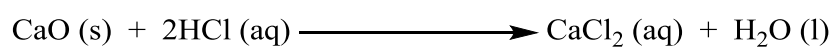
**D** is the correct answer.

60. *CaO (s) and HCl (aq) will react to give:*

- (A). *CaCl and H<sub>2</sub>O*
- (B). *Ca(OH)<sub>2</sub> and Cl<sub>2</sub>*
- (C). *CaH and Cl<sub>2</sub>*
- (D). *CaCl<sub>2</sub> and H<sub>2</sub>O*

**Solution:**

- A metallic oxide will react with an acid to yield a salt and water
- The specific reaction occurring here is:



**D** is the correct answer.