SUGGESTED ANSWERS TO THE PART 01: REVISION EXERCISES

Multiple Choice Questions (HW)

i. Spring water decomposes on boiling to produce white solid particles. The solid particles are:

- **Answer: C. Magnesium carbonate**
- **Explanation:** Magnesium hydrogencarbonate ($Mg(HCO_3)_2$) is responsible for temporary hardness in water. On boiling, it decomposes into magnesium carbonate ($MgCO_3$, a white solid), carbon dioxide (CO_2), and water (H_2O):
  $Mg(HCO_3)_2\,(aq) \rightarrow MgCO_3(s) + CO_2(g) + H_2O(l)$

ii. Which one of the following pairs of compounds can cause temporary hardness of water?

- **Answer: D. Magnesium hydrogencarbonate and calcium hydrogencarbonate**
- **Explanation:** Temporary hardness is caused by bicarbonates (hydrogencarbonates) of calcium and magnesium, which decompose upon boiling.

iii. Which of the following reagents is used for softening hard water?

- **Answer: A. Na_2CO_3**
- **Explanation:** Sodium carbonate (washing soda) softens hard water by precipitating calcium and magnesium ions as insoluble carbonates:
  $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$

iv. Which one of the following compounds does not cause hardness of water?

- **Answer: B. Sodium hydrogencarbonate**
- **Explanation:** Sodium salts are soluble and do not contribute to water hardness, unlike calcium and magnesium compounds.

v. Which one of the following processes is not used to remove hardness in water?

- **Answer: D. Addition of sodium structure**

vi. Which one of the following is most common in hard water?

- **Answer: D. Mg^{2+}**
- **Explanation:** Magnesium (Mg^{2+}) and calcium (Ca^{2+}) ions are the primary causes of hardness, with Mg^{2+} being very common alongside Ca^{2+}.

vii. Which one of the following compounds does not cause hardness of water?

- **Answer: B. Sodium carbonate**

viii. How is permanent hardness of water removed?

- **Answer: C. By adding washing soda**
- **Explanation:** Permanent hardness (due to sulfates or chlorides) is removed by adding sodium carbonate (Na_2CO_3), which precipitates Ca^{2+} and Mg^{2+} as carbonates. Boiling only removes temporary hardness.

ix. One advantage of hard water is that:

- **Answer: C. It contains calcium compounds which help to form healthy bones**

x. Which one of the following types of water would take the greatest amount of soap solution to form lather using the same volume of each type?

- **Answer: C. Sea water**
- **Explanation:** Sea water contains high levels of dissolved salts (including Ca^{2+} and Mg^{2+}), requiring more soap to overcome hardness and form lather.

xi. Potassium aluminium sulphate (potash alum) is used during the purification of water for:

- **Answer: C. Removing suspended matter**
- **Explanation:** Potash alum ($KAl(SO_4)_2$) acts as a coagulant, helping to settle suspended particles in water purification.

xii. Permanent hard water can be softened by:

- **Answer: D. Adding sodium carbonate**
- **Explanation:** Sodium carbonate removes permanent hardness by precipitating Ca^{2+} and Mg^{2+} ions as insoluble carbonates.

Short Answer Questions

2. (a) Name one compound that causes:

- **(i)** Calcium sulphate ($CaSO_4$)
- **(ii)** Calcium hydrogencarbonate ($Ca(HCO_3)_2$)

(b) It forms scale in boilers and pipes, reducing efficiency.

(c) (i) $Ca^{2+} + Na_2R \rightarrow CaR + 2Na^+$
(where R represents the resin in an ion-exchange column)

(ii) Ion exchange works by replacing Ca^{2+} and Mg^{2+} ions in hard water with Na^+ ions from a ion-exchange column.

3. Table Analysis

Sample	Before boiling (cm^3)	After boiling (cm^3)
P	2	2
Q	8	8
R	5	3

(a) Identify which sample was:

- **(i) Rain water**
  - **Answer: P**
  - **Reason:** Rain water is soft, requiring minimal soap (2 cm^3), unchanged by boiling.
- **(ii) Temporary hard water**

- **Answer: R**
- **Reason:** Volume of soap required to form lather decreased after boiling (from 5cm^3 to 3 cm^3), indicating removal of temporary hardness.

- **(iii) Permanent hard water**
  - **Answer: Q**
  - **Reason:** The volume of soap required to form lather was high (8 cm^3) and was unchanged by boiling, indicating this water was permanent hard water.

(b) Name one substance which can cause permanent hardness in water

- **Answer:** Magnesium sulphate ($MgSO_4$)

4. (a) What is meant by hard water?

- **Answer:** Hard water is the water that does not lather readily with soap because it contains dissolved calcium and magnesium ions.

(b) (i) Name two ions responsible for the hardness of water

- **Answer:** Calcium ions (Ca^{2+}) and Magnesium ions (Mg^{2+})

(ii) Write an ionic equation for the reaction that takes place when soap solution is added to hard water

- **Answer:** $Ca^{2+}(aq) + C_{17}H_{35}COO^-(aq) \rightarrow (C_{17}H_{35}COO)_2Ca(s)$
  (scum)

(iii) State one advantage of hard water

- **Answer:** Provides calcium for healthy bones and teeth.

Chemical Equations

5. Symbolic chemical equations:

- **(a)** $NaOH + HCl \rightarrow NaCl + H_2O$
- **(b)** $K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + CO_2 + H_2O$
- **(c)** $2Na + 2H_2O \rightarrow 2NaOH + H_2$
- **(d)** $Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4(s) + 2NaNO_3$

6. Word and symbolic equations:

- **(a)** Sulphur + oxygen → sulphur dioxide
  $S + O_2 \rightarrow SO_2$
- **(b)** Methane + oxygen → carbon dioxide + water
  $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- **(c)** Zinc + hydrochloric acid → zinc chloride + hydrogen
  $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

- **(d)** Copper oxide + hydrogen → copper + water
  $CuO + H_2 \rightarrow Cu + H_2O$

7. Balanced chemical equations:

- **(a)** $2Ca + O_2 \rightarrow 2CaO$
- **(b)** $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
- **(c)** $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$
- **(d)** $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4(s) + 2NaCl$

8. Balanced equations:

- **(a)** $2H_2 + O_2 \rightarrow 2H_2O$
- **(b)** $N_2 + 3H_2 \rightarrow 2NH_3$
- **(c)** $2Cu + 2NO_2 \rightarrow 2CuO + N_2$
- **(d)** $3CuO + 2NH_3 \rightarrow 3Cu + 3H_2O + N_2$

Chemical Equation: Additional Exercises

1. Write word equations:

i) Carbon + oxygen → carbon dioxide
ii) Hydrogen + oxygen → steam
iii) Sodium hydroxide + sulphuric acid → sodium sulphate + water
iv) Methane + oxygen → carbon dioxide + water

2. Convert to symbolic equations:

i) $N_2 + 3H_2 \rightarrow 2NH_3$
ii) $S + O_2 \rightarrow SO_2$
iii) $Fe + S \rightarrow FeS$

3. Balance the following:

i) $4Li + O_2 \rightarrow 2Li_2O$
ii) $Mg + 2HNO_3 \rightarrow Mg(NO_3)_2 + H_2$
iii) $2Zn(NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2$
iv) $3Cl_2 + 6KOH \rightarrow 5KCl + KClO_3 + 3H_2O$
v) $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$
vi) $2FeCl_2 + Cl_2 \rightarrow 2FeCl_3$

4. Translate to word equations:

i) Sodium + chlorine → sodium chloride
ii) Calcium carbonate + nitric acid → calcium nitrate + carbon dioxide + water
iii) Zinc + hydrochloric acid → zinc chloride + hydrogen
iv) Iron + copper(II) sulphate → iron(II) sulphate + copper

5. Write balanced equations:

(a) $2Ca + O_2 \rightarrow 2CaO$
(b) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
(c) $2Pb(NO_3)_2 \rightarrow 2PbO + 4NO_2 + O_2$
(d) $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4(s) + 2NaCl$

6. Show chemical formulae using:

(a) Balancing of charges / (b) Interchanging valencies:
i) Aluminum chloride: **$AlCl_3$**
ii) Sodium nitrate: **$NaNO_3$**
iii) Magnesium hydrogen carbonate: **$Mg(HCO_3)_2$**
iv) Zinc nitrate: **$Zn(NO_3)_2$**

Acids, Bases and Salts

ABS Multiple Choice Questions

i. B. Sodium hydroxide
ii. D. The salt of the metal and hydrogen gas
iii. D. Silver carbonate
iv. D. pH = 2

v. Reactions of sulphuric acid with:
(a) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
(b) $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$
(c) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$
(d) $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$
(e) $2NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2CO_2 + 2H_2O$

Short Answer Questions (Acids, Bases and Salts)

1. (a) What is an acid?

- **Answer:** An acid is a substance which when dissolved in water produces hydrogen ions (H^+) as the only positively charged ions.

(b) State three physical properties of acids

- **Answer:**

    1. They have sour taste (e.g., lemon juice).
    2. They turn blue litmus paper red.
    3. They conduct electricity in aqueous solution due to ion presence.

(c) Write the name and formula of the 3 common mineral acids used in the laboratory

- **Answer:**

1. Hydrochloric acid – HCl
2. Sulphuric acid – H_2SO_4
3. Nitric acid – HNO_3

(d) Write chemical equations to illustrate the properties of acids using hydrochloric acid and the following compounds:

- **(i) Copper(II) oxide**
  - $2HCl + CuO \rightarrow CuCl_2 + H_2O$
- **(ii) Magnesium metal**
  - $Mg + 2HCl \rightarrow MgCl_2 + H_2$
- **(iii) Potassium carbonate solution**
  - $K_2CO_3 + 2HCl \rightarrow 2KCl + CO_2 + H_2O$
- **(iv) Potassium hydrogen carbonate solution**
  - $KHCO_3 + HCl \rightarrow KCl + CO_2 + H_2O$

2. A bee sting contains methanoic acid. That is why it is so painful. How then can you treat someone who has been stung by a bee?

- **Answer:** Apply a weak base, such as sodium hydrogen carbonate (baking soda) solution, to neutralize the methanoic acid (HCOOH) and reduce pain:

  The equation:
  $HCOOH + NaHCO_3 \rightarrow HCOONa + CO_2 + H_2O$

3. Which ions are responsible for:

- **(a) Acidic properties?**
  - **Answer:** H^+ (hydrogen ions)
- **(b) Basic properties?**
  - **Answer:** OH^- (hydroxide ions)

4. Define the term tribasic salt

- **Answer: A tribasic salt** is an acid that dissociates to produce three hydrogen ions when dissolved in water.

5. (a) Define the terms:

- **(i) Base**
  - **Answer:** A substance that neutralizes an acid by reacting with hydrogen ions.
- **(ii) Alkali**
  - **Answer: Alkali** is base which is soluble in water and produces hydroxide ions as the only negatively charged ions.
- **(iii) Neutralization reaction**

- **Answer:** A reaction between an acid and a base to form a salt and water.

(b) Give two examples of:

- **(i) Bases**
  - Magnesium oxide (MgO)
  - Calcium hydroxide ($Ca(OH)_2$)
- **(ii) Alkalis**
  - Sodium hydroxide (NaOH)
  - Potassium hydroxide (KOH)

(b) Describe an experiment to prepare an indicator in the laboratory from either colored flower petals or red cabbage leaves

- **Answer:**
  1. Crush red cabbage leaves or flower petals (e.g., hibiscus) in a mortar with a pestle.
  2. Add a small amount of water or ethanol to extract the pigments.
  3. Filter the mixture to obtain a colored solution.
  4. Test the solution with acids (turns red/pink) and bases (turns green/blue) to confirm it works as an indicator.

(c) Match the acid with the salt name associated with it:

- **Answer:**
  - i. Nitric acid – (c) Nitrates
  - ii. Hydrochloric acid – (a) Chlorides
  - iii. Carbonic acid – (d) Carbonates
  - iv. Sulphuric acid – (b) Sulphates

6. State whether these acids form normal salts only or can form both normal and acid salts:

- (a) Carbonic acid – Both (e.g., Na_2CO_3, $NaHCO_3$)
- (b) Hydrochloric acid – Normal only (e.g., NaCl)
- (c) Sulphuric acid – Both (e.g., Na_2SO_4, $NaHSO_4$)
- (d) Nitric acid – Normal only (e.g., $NaNO_3$)

7. Give the names of salts formed when:

- **(a) Sodium metal replaces hydrogen ions of nitric acid**
  - Sodium nitrate ($NaNO_3$)
- **(b) Calcium metal partially replaces hydrogen ion of carbonic acid**
  - Calcium hydrogencarbonate ($Ca(HCO_3)_2$)

- **(c) Ammonium ion replaces the hydrogen ions of hydrochloric acid**
    - Ammonium chloride (NH_4Cl)
- **(d) Potassium metal partially replaces the hydrogen ion of sulphuric acid**
    - Potassium hydrogen sulphate ($KHSO_4$)

8. Complete the table:

Name of salt	Formulae of salt	Source (acid)
Zinc nitrate	(a) $Zn(NO_3)_2$	(b) Nitric acid
(c) Potassium sulphate	K_2SO_4	(d) Sulphuric acid
(e) Sodium chloride	(f) NaCl	Hydrochloric acid
Ammonium sulphate	(g) $(NH_4)_2SO_4$	(h) Sulphuric acid

9. Direct reaction between calcium carbonate and dilute sulphuric acid is not advisable in the preparation of calcium sulphate. Explain.

- Answer: The reaction forms insoluble calcium sulphate ($CaSO_4$), which coats the calcium carbonate ($CaCO_3$), preventing further reaction:
  $CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + CO_2(g) + H_2O(l)$

10. (a) Comment on the solubility of calcium sulphate and lead(II) chloride

- **Answer:**
    - Calcium sulphate ($CaSO_4$): Slightly soluble in water.
    - Lead(II) chloride ($PbCl_2$): Insoluble in cold water.

(b) State an example of a salt which exists as:

- **(i) White crystal –** Sodium chloride (NaCl)
- **(ii) White powder –** Calcium carbonate ($CaCO_3$)

11. Give the general name given to the salts derived from the following acids:

- **(a) Nitric acid –** Nitrates
- **(b) Carbonic acid –** Carbonates
- **(c) Sulphuric acid** – Sulphates

12. (a) What do you understand by the term salt?

Salt is a compound formed when the hydrogen of an acid is replaced by a metal or ammonium ion.

(b) A certain salt is made when ammonium ion displaces all the hydrogen ion of sulphuric acid. Give the name and formula of the salt formed.

- **Answer:** Ammonium sulphate, $(NH_4)_2SO_4$

13. (a) Name two metal carbonates, which do not decompose when heated

- **Answer:**
    1. Sodium carbonate (Na_2CO_3)
    2. Potassium carbonate (K_2CO_3)

(b) Name the products formed when the following carbonates are heated:

- **(i) Zinc carbonate** – Zinc oxide (ZnO) + Carbon dioxide (CO_2)
- **(ii) Lead(II) carbonate** – Lead(II) oxide (PbO) + Carbon dioxide (CO_2)

(c) Write equations to show the action of heat on the carbonates in (b)

- **(i)** $ZnCO_3 \rightarrow ZnO + CO_2$
- (ii) $PbCO_3 \rightarrow PbO + CO_2$

(d) Write a chemical equation to represent the action of heat on sodium hydrogen carbonate

- **Answer:** $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

14. (a) State and explain the observation made when hydrated copper(II) sulphate crystals are heated gently then strongly

- **Answer:**
    - **Gently heating:** *Crystals lose water, turning from blue to white anhydrous* $CuSO_4$*; steam is observed.*
    - **Equation:** $\mathbf{CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 + 5H_2O}$
    - **Strongly heating:** *The white copper(II) sulphate further decomposes to produce black copper(II) oxide and releases fumes of sulphur trioxide* (SO_3)
    - $\mathbf{CuSO_4 \rightarrow CuO + SO_3}$ (strong heating)

(b) State and explain the observations made when anhydrous iron(II) sulphate is heated gently then strongly

- **Answer:**
    - **Gently:** *Begins to decompose, forming iron(III) oxide* (Fe_2O_3)*,* SO_2*, and* SO_3 *gases; color changes to reddish-brown.*
    - **Strongly***: Complete decomposition with gas evolution.*
    - *Equation:* $2FeSO_4 \rightarrow Fe_2O_3 + SO_2 + SO_3$

(c) Write equations for the reactions that occur in 14(a) and (b) above

- **Already provided above.**

15. (a) Predict the products that would be formed if the following nitrates are heated:

- **(i) Calcium nitrate –** Calcium oxide (CaO), Nitrogen dioxide (NO_2), Oxygen (O_2)
- **(ii) Magnesium nitrate –** Magnesium oxide (MgO), Nitrogen dioxide (NO_2), Oxygen (O_2)

(b) Write equations for the reactions in 14(a) above

- (i) $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$
- (ii) $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

15.(i) **Gently:** Blue to white and steam; Strongly: copper (II) sulphate decomposes to copper oxide and sulphur trioxide
(i) $\mathbf{CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 + 5H_2O}$

16.(a) $FeSO_4$: Normal salt
(b) $NaHCO_3$: Acidic salt
(c) $ZnBr_2$: Normal salt
(d) PbI_2: Normal salt

16.(i) $AgNO_3$: Soluble
(ii) $Zn(NO_3)_2$: Soluble
(iii) $CaCO_3$: Insoluble
(iv) $MgSO_4$: Soluble
(v) $NaHSO_4$: Soluble
(vi) $PbCl_2$: Insoluble
(vii) $BaSO_4$: Insoluble
(viii) AgCl: Insoluble

17.(a) The products are sodium carbonate, carbon dioxide and water
(b) $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

18.(a)
(i) gas Y is carbon dioxide $\mathbf{CO_2}$
(ii) **Zinc oxide (ZnO)**
(b) **White**
(c) **Zinc (Zn)**

20. (a) and (b) refer question 17

(c)(i) T (pH 2.0)
(ii) W (pH 11.0)
(iii) T (pH 2.0)
(iv) U (pH 7.0)
(d)(i) Lactic acid
(ii) Citric acid
(iii) Tannic acid
(iv) Methanoic acid

21.(a) **Strong acid** is an acid that ionizes completely when dissolved in water and forms high amount of hydrogen ions;

Basicity is the number of hydrogen ions that can be produced by one molecule of an acid //

Basicity is the number of replaceable hydrogen ions in a molecule of an acid.
(b)(i) **White precipitate was observed.**
(ii) $\mathbf{Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4(s) + 2HNO_3}$
(white ppt)
(b)(i) $\mathbf{ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + CO_2 + H_2O}$
(ii) $\mathbf{2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O}$
(iii) $\mathbf{Mg + H_2SO_4 \rightarrow MgSO_4 + H_2}$

22.(a)(i) **Basicity** is the number of hydrogen ions that can be produced by one molecule of an acid.
Examples hydrochloric acid (HCl) is monobasic acid while phosphoric acid is tribasic acid (H_3PO_4).
(ii) **Acid salt** is a salt formed when replaceable hydrogen ions of an acid are partially replaced by metallic ion or ammonium ion **eg.** $NaHSO_4$.
(b)-Neutralize dilute sulphuric acid with sodium hydroxide solution using an indicator to determine end point.

-Repeat neutralization without the indicator using the same volumes of acid and base

- Evaporate the solution to dryness.

- Dry the sodium sulphate crystals by placing them in the dessicator.

23.(a) **Efflorescence** is the process whereby a substance/salt loses water of crystallization to the atmosphere. **OR** is the loss of water of crystallization by a hydrated salt when exposed to air.
(b) **Hygroscopic salt** is a salt that absorbs water from the atmosphere and does not form solution **while** hygroscopy is the process of absorbing water from the atmosphere without forming solution.