Answers to Self-Check Questions

Q1a

$MgCO_3(s) \xrightarrow[\text{heat}]{} MgO(s) + CO_2(g)$

Q1b

Mg^{2+} ion has a smaller ionic radius than the Ba^{2+} ion. Thus, the Mg^{2+} ion has a higher charge density and consequently a stronger polarising power than the Ba^{2+} ion. The more polarising Mg^{2+} ion distorts the electron cloud of the CO_3^{2-} anion to a larger extent and hence weakens the covalent bonds within the CO_3^{2-} anion to a greater extent. Thus, less heat energy is required to decompose $MgCO_3$ than $BaCO_3$. Hence $MgCO_3$ decomposes at a lower temperature than $BaCO_3$.

Q1c

$$\left| \text{lattice energy} \right| \propto \left| \frac{q_+ \times q_-}{r_+ + r_-} \right|$$

Mg^{2+} has the same charge as Ba^{2+} but Mg^{2+} has a smaller ionic radius than Ba^{2+}. Hence the magnitude of the lattice energy of $MgCO_3$ is larger than that of $BaCO_3$.

Q2a

$MCO_3(s) \longrightarrow MO(s) + CO_2(g)$

Mass of CO_2 produced = 1.34 g

Amount of $CO_2 = \frac{1.34}{44.0}$ = 0.03045 mol

Amount of MCO_3 = 0.03045 mol

Mass of 0.03045 mol of MCO_3 = 4.50 g

Mass of 1 mol of MCO_3 = 147.8 g

M_r of MCO_3 = 147.8

A_r of M = 147.8 – 12.0 – (3)(16.0) = 87.8

Hence M is Sr.

Q2b

$CaMg(CO_3)_2(s) + 4H^+(aq) \rightarrow Ca^{2+}(aq) + Mg^{2+}(aq) + 2CO_2(g) + 2H_2O(l)$

Amount of CO_2 = 0.45/44.0 = 0.01023 mol

Amount of $CaMg(CO_3)_2 = (½)(0.01023)$
= 0.005115 mol

Mr of $CaMg(CO_3)_2$ = 184.4

Mass of $CaMg(CO_3)_2$ = 0.005115 x 184.4
= 0.943 g

Percentage purity of dolomite
= 0.943/1.00 x 100% = 94.3%

Q2c

$CaSO_4.2H_2O \longrightarrow CaSO_4.nH_2O + (2–n)\ H_2O$

Molar mass of $CaSO_4.2H_2O$ = 172.2

Amount of $CaSO_4.2H_2O = \frac{100}{172.2}$ = 0.5807 mol

Mass of H_2O lost = 15.7 g

Amount of H_2O lost $= \frac{15.7}{18.0}$ = 0.8722 mol

Molar ratio of $CaSO_4.2H_2O$ to H_2O
= 1 : (2–n)
= 0.5807 : 0.8722 = 1 : 1.5

Hence (2 – n) = 1.5
n = 0.5

∴formula of plaster of Paris is $CaSO_4.½H_2O$

Q2d(i)

Mass of gaseous mixture = 1.00 – 0.438
= 0.562 g

Amt of gases = 374/24000 = 0.01558 mol

Average molar mass of gaseous mixture
= 0.562 / 0.01558 = 36.1 g mol^{-1}

Average M_r = 36.1

Q2d(ii)

The gas which reacted with NaOH(aq) is CO_2.

Q2d(iii)

Let the other gas be X.

Volume of CO_2 = 187 cm^3

Volume of X = 374 – 187 = 187 cm^3

Since volume of X = volume of CO_2, the mixture contains equal amounts of the X and CO_2.

Mole fraction of each gas = ½

$(½)(M_r \text{ of X}) + (½)(M_r \text{ of } CO_2) = 36.1$
$(½)(M_r \text{ of X}) + (½)(44.0) = 36.1$
M_r of X = 28.2

Hence X is CO.

Q2d(iv)

E is CaC_2O_4.

$CaC_2O_4(s) \longrightarrow CaO(s) + CO(g) + CO_2(g)$

Q3

	chlorine	bromine	iodine
Physical state at rtp	gas	liquid	solid

Trend:

Volatility decreases in the order: $Cl_2 > Br_2 > I_2$.

Explanation:

- Cl_2, Br_2 and I_2 exist as simple, non–polar diatomic molecules with intermolecular instantaneous dipole–induced dipole (id–id) interactions.
- Boiling involves overcoming these intermolecular id–id attractions.
- From Cl_2 to I_2, the size of the electron cloud increases. Thus, the electron cloud becomes more easily distorted/ polarisable,
- The id–id attractions become stronger and more energy is required to break the intermolecular forces of attraction

- Hence, boiling point increases in the order: $Cl_2 < Br_2 < I_2$ and volatility decreases in the order: $Cl_2 > Br_2 > I_2$.

Q4 (Ans: D)

Displacement reaction has occurred.
$Cl_2(aq) + 2Br^-(aq) \longrightarrow 2Cl^- + Br_2$
Since CCl_4 is immiscible and denser than water, the bottom layer should be orange-red in colour.

Note: As most non-polar Br_2 entered the non-polar CCl_4 solvent (due to formation of favourable id-id interactions), the concentration of Br_2 in the aqueous layer is low and hence its colour is less intense (it appears yellow instead of orange).

Q5(a)

$$2NaAt(aq) + Br_2(aq) \longrightarrow 2NaBr(aq) + At_2(s)$$

Observations: Orange $Br_2(aq)$ is decolourised. A black solid, At_2, is formed.

Q5(b)

$$AgNO_3(aq) + NaAt(aq) \longrightarrow AgAt(s) + NaNO_3(aq)$$

Observations: A yellow precipitate, AgAt, is formed. Ppt is insoluble in excess $NH_3(aq)$.

Q6 (Ans: C)
Reaction of iodine with thiosulfate:
$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$

Reaction of chlorine with thiosulfate:
$S_2O_3^{2-}(aq) + 4Cl_2(aq) + 5H_2O(l)$
$\longrightarrow 2SO_4^{2-}(aq) + 8Cl^-(aq) + 10H^+(aq)$

Upon addition of $Ba(NO_3)_2(aq)$:
$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4(s)$
ppt **T**

Addition of $AgNO_3(aq)$ to filtrate:
$Ag^+(aq) + I^-(aq) \longrightarrow AgI(s)$
ppt **U**

Note: $AgCl(s)$ is also formed, but it dissolves in excess $NH_3(aq)$.

Q7 (Ans: D)

When $CH_2ClCHICO_2H$ is heated with Na, NaCl and NaI are formed.

Upon addition of $AgNO_3(aq)$:
$Ag^+(aq) + I^-(aq) \longrightarrow AgI(s)$
yellow ppt

$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$
white ppt

Upon addition of conc NH_3, $AgCl(s)$ dissolves and only $AgI(s)$ remains insoluble. Hence, the precipitate in the solution appears 'more yellow' in colour.