Neap

Trial Examination 2023

Suggested Solutions

QCE Chemistry Units 1&2

Paper 2

SECTION 1

QUESTION 1 (5 marks)

a) Ionic radii increase down a group. Moving down a group, the effective nuclear charge of each ion stays constant, but the number of shells increases. As a result, the ionic radii increase.

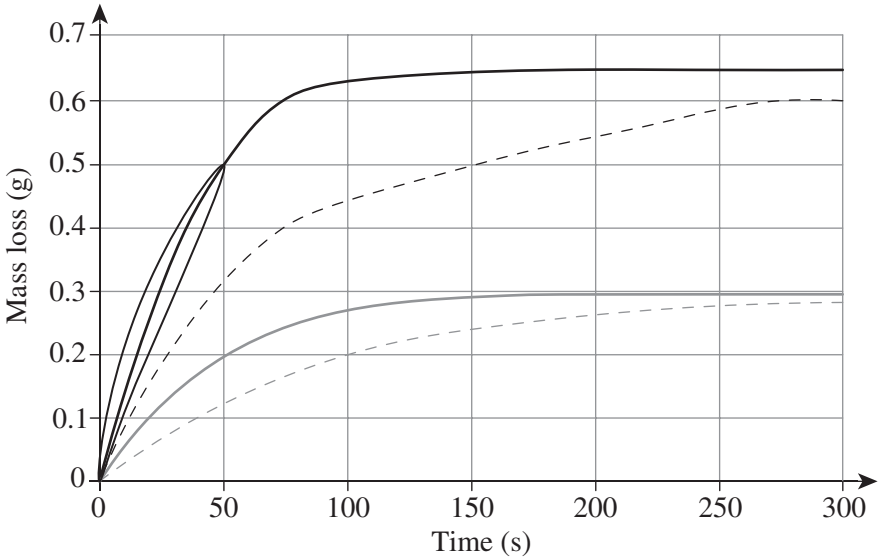
[2 marks]
1 mark for identifying the trend.
1 mark for explaining the trend.

b) The cations, which lose electrons, of group 3 (Na^+ to P^{5+}) all have empty 3s and 3p orbital shells ($1s^2 2s^2 2p^6$). The positive charge of the nucleus exerts a strong force of attraction on the 2s and 2p electrons. The anions of the same group (S^{2-} and Cl^-) have extra electrons that completely fill the 3s and 3p orbital shells ($1s^2 2s^2 2p^6 3s^2 3p^6$). In each anion, these 3s and 3p electrons are further away from the nucleus compared to the 2s and 2p electrons in the cations. This means the pull of the positive nucleus is not as strong, and so the anions' radii are larger. Therefore, the anions are larger than the cations as they have an extra layer of filled orbital shells.

[3 marks]
1 mark for explaining the size of period 3 cations in terms of electron shells and effective nuclear charge.
1 mark for explaining the size of period 3 anions in terms of electron shells and effective nuclear charge.
1 mark for explaining the difference between the cation and anion sizes.

QUESTION 2 (9 marks)

a)



[1 mark]
1 mark for circling the correct time period on the 3.0 M HCl and small chips curve.

b) The mass loss was relatively rapid during the first 70 seconds and gradually slowed before evening out at around 260 seconds.

[2 marks]
1 mark for describing the initial rapid mass loss.
1 mark for describing the gradual slowing and evening out of mass loss.

c) *For example:*

As 3.0 M HCl contains twice the number of acid particles as 1.5 M HCl, there is double the chance that the HCl and marble chip particles will collide and react, thus producing more carbon dioxide (CO_2) and increasing mass loss.

From 0–100 seconds, the curve for the reaction using 3.0 M HCl and small chips is significantly steeper than the curve for 1.5 M HCl and small chips reaction, and the mass loss is more than double. After 100 seconds, both curves gradually flatten, and the overall mass loss of the 3.0 M HCl reaction (0.65 g) is more than double that of the 1.5 M HCl reaction (0.3 g). This shows that the rate of the 3.0 M HCl reaction is approximately double that of the 1.5 M HCl reaction due to the higher acid concentration.

[4 marks]
1 mark for outlining the difference in acid concentrations.
1 mark for explaining how the difference in concentrations affects collisions.
1 mark for explaining the differences between the curves of the reactions.
1 mark for stating that the 3.0 M HCl reaction has a faster rate of reaction.
Note: Accept other appropriate responses.

d) *Any two of:*

- Gases are difficult to collect as they are easily lost through gaps in equipment.
- It is difficult to measure the volume of gases accurately.
- The volume of CO_2 produced would have been very small.
- An electronic balance enables the mass loss from reactants over a time period to be recorded; it would be difficult to record the mass loss over a time period by collecting the CO_2 produced.

[2 marks]
1 mark for each reason identified.

QUESTION 3 (6 marks)

a) **Experiment A:** A precipitate of copper hydroxide ($Cu(OH)_2$) formed as it is insoluble.

Experiment B: A precipitate did not form as both products, iron(II) nitrate ($Fe(NO_3)_2$) and potassium chloride (KCl), are soluble.

[2 marks]
1 mark for deducing that experiment A formed a precipitate and providing a reason.
1 mark for deducing that experiment B did not form a precipitate and providing a reason.

b) $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$

[2 marks]
1 mark for identifying the products and reactants.
1 mark for balancing the equation.
Note: States are not required to obtain full marks.

c) Solubility is dependent on concentration and temperature. If the concentrations of the reactants were not high enough, then there would have been insufficient collisions to produce a reaction and thus form a precipitate.

[2 marks]
1 mark for stating that solubility is dependent on concentration.
1 mark for proposing that the concentrations of the reactants may have been insufficient.

QUESTION 4 (4 marks)

a) yellow dye

[1 mark]
1 mark for identifying yellow dye.
Note: The yellow dye travelled the furthest distance in experiment 1 but the shortest distance in experiment 2. It also shows the biggest change in R_f value between the two experiments.

b) Ethanol is more polar. It has a hydrogen atom attached to an oxygen atom, which allows it to form hydrogen bonds that strongly attach substances to the solvent. This allows them to move in the mobile phase.

[2 marks]
1 mark for identifying that ethanol is more polar.
1 mark for explaining why ethanol is more polar in terms of its hydrogen bonds.

c) As water is polar, propan-2-one and ethanol were mixed with it to increase or decrease the polarity of the water in order to enable more substances to dissolve in the solvent.

[1 mark]
1 mark for identifying that water is polar and explaining that propan-2-one and ethanol were mixed with water to change the polarity.

QUESTION 5 (7 marks)

$PV = nRT$

$P = 111.4575$ kPa

$V = 47.0$ L

$R = 8.31$ J mol^{-1} K^{-1}

$T = 150 + 273 = 423$ K

$$n(CO_2) = \frac{PV}{RT}$$
$$= \frac{111.4575 \times 47.0}{8.31 \times 423}$$
$$= 1.4903 \text{ mol}$$

The ratio of octane (C_8H_{18}) to carbon dioxide (CO_2) according to the equation is 2 : 16 = 1 : 8.

Calculating the amount of C_8H_{18} reacted gives:

$$n(C_8H_{18}) = \frac{1.4903}{8}$$
$$= 0.1863 \text{ mol}$$

Calculating the molar mass of C_8H_{18} gives:

$$M(C_8H_{18}) = (8 \times 12.01) + (18 \times 1.01)$$
$$= 96.08 + 18.18$$
$$= 114.26$$

Calculating the mass of C_8H_{18} reacted gives:

$$m(C_8H_{18}) = 0.1863 \times 114.26$$
$$= 21.3 \text{ g}$$

[7 marks]

1 mark for recognising that the ideal gas equation needs to be used. Note: This may be implied by subsequent working.

1 mark for converting pressure and temperature.

1 mark for substituting into the equation.

1 mark for determining the ratio of C_8H_{18} to CO_2.

1 mark for calculating the amount of C_8H_{18} reacted.

1 mark for calculating the molar mass of C_8H_{18}.

1 mark for calculating the mass of C_8H_{18} reacted.

Note: Allow follow-through errors.

QUESTION 6 (6 marks)

$\Delta T = T_{\text{final}} - T_{\text{initial}} = 31.0 - 25.0 = 6.00°\text{C}$

Calculating the mass of water (H_2O) gives:

$$m(\text{H}_2\text{O}) = \text{volume} \times \text{density}$$
$$= 40.0 \times 1.00$$
$$= 40.0 \text{ g}$$

$c_{\text{w}} = 4.18 \text{ J g}^{-1} \text{ K}^{-1}$

Calculating Q gives:

$$Q = mc\Delta T$$
$$= 40.0 \times 4.18 \times 6.00$$
$$= 1003.2 \text{ J}$$
$$= 1.0032 \text{ kJ}$$

The heat gained by the water comes from the reaction, so the reaction is exothermic.

$\therefore Q = -1003.2$ kJ

$n(\text{HCl}) = n(\text{NaOH}) = 0.034$ mol

Calculating ΔH gives:

$$\Delta H = \frac{Q}{n}$$
$$= \frac{-1.0032}{0.034}$$
$$= -29.5 \text{ kJ mol}^{-1}$$

[6 marks]

1 mark for calculating the change in temperature.

1 mark for calculating the mass of water.

1 mark for recognising that the specific heat formula needs to be used. Note: This may be implied by subsequent working.

1 mark for calculating Q.

1 mark for determining that the reaction is exothermic. Note: This may be implied by the use of the negative value.

1 mark for calculating ΔH.

QUESTION 7 (6 marks)

a) sucrose ($C_{12}H_{22}O_{11}$)

[1 mark]
1 mark for identifying sucrose.

b) The solubility of sodium nitrate ($NaNO_3$) increases slightly from 0°C to 50°C *(from 75 g per 100 g to 120 g per 100 g)*, and then increases more rapidly from 50°C to 90°C *(from 120 g per 100 g to 175 g per 100 g)*.

[1 mark]
1 mark for describing the change in solubility.

c) $C_{12}H_{22}O_{11}$ is the most polar. Since water is polar, the most polar of the three substances will have the highest solubility.

[2 marks]
1 mark for deducing that $C_{12}H_{22}O_{11}$ is the most polar.
1 mark for explaining the relationship between polarity and solubility.

d) The solution is saturated. If 250 g of $C_{12}H_{22}O_{11}$ is added at 0°C, only 180 g will dissolve, and the remaining 70 g will be unable to dissolve.

[2 marks]
1 mark for determining that the solution is saturated.
1 mark for explaining that some of the $C_{12}H_{22}O_{11}$ will not dissolve.

QUESTION 8 (7 marks)

a) Atomic absorption spectroscopy (AAS) enables the accurate measurement of very small concentrations of metals in water and other substances.

[1 mark]
1 mark for stating the advantage.

b) 2.55 ppm

[1 mark]
1 mark for determining the concentration.
Note: Accept values in the range of 2.55–2.60 ppm.

c) The sample is diluted by a factor of 10.

concentration in the undiluted sample = 10 × 2.55 = 25.50 ppm

[1 mark]
1 mark for determining the concentration.
*Note: Consequential on answer to **Question 8b)**.*

d) 25.50 ppm = 25.50 g of iron per 10^6 g of drink

$$m(\text{iron in 200 mL}) = \frac{25.50 \times 200}{10^6}$$
$$= 5.10 \times 10^{-3} \text{ g}$$

[2 marks]
1 mark for converting the concentration.
1 mark for calculating the mass.
*Note: Consequential on answer to **Question 8c)**.*

e) 5.10×10^{-3} g = 5.10 mg

$$\text{percentage of RDI} = \frac{5.10}{8.00} \times 100$$
$$= 63.75\%$$

[2 marks]
1 mark for converting the mass.
1 mark for calculating the percentage.
*Note: Consequential on answer to **Question 8d)**.*