

Suggested Answers

VCE Chemistry 2016 Year 11 Trial Exam Unit 2

SECTION A – Multiple Choice Answers

(1 mark per question)

- Q1. C** Referring to the *VCE Chemistry Data Book: Table 3*
Specific heat capacity for water: $c = 4.18 \text{ J g}^{-1} \text{ }^\circ\text{C}^{-1}$
Density of water = 1.00 g mL^{-1}
 $5.00 \text{ L} = 5.00 \times 1000 = 5000 \text{ mL} = 5000 \text{ g}$
 $\Delta T = 95.0 - 25.0 = 70.0 \text{ }^\circ\text{C}$
 $Q = m \times c \times \Delta T = 5000 \times 4.18 \times 70.0 = 1.46 \times 10^6 \text{ J}$
 $Q = 1.46 \times 10^6 / 1000 = 1460 \text{ kJ}$
- Q2. B** Like hydrogen sulfide, water is a Group 16 hydride.
The boiling point of hydrogen sulfide is significantly lower than that for water ($-60 \text{ }^\circ\text{C}$ compared to $100 \text{ }^\circ\text{C}$).
Since the boiling temperature reflects the bonding interactions **between** the molecules, the forces attracting the water molecules to each other are greater. Both water and hydrogen sulfide are polar molecules because of the difference in the electronegativities of hydrogen, oxygen and sulfur. Therefore there will be dipole-dipole interactions between both H_2O and H_2S molecules. However, in water there are stronger hydrogen bonding interactions between the molecules and this accounts for the increased temperature of the boiling point.
- Q3. C** All common nitrate compounds are soluble in water.
Chlorides other than those of silver and lead(II) are soluble.
Therefore, when aqueous solutions of cobalt(II) chloride and silver nitrate are mixed, a precipitate of silver chloride will form.
Full equation:
 $\text{CoCl}_2(\text{aq}) + 2\text{AgNO}_3(\text{aq}) \rightarrow \text{Co}(\text{NO}_3)_2(\text{aq}) + 2\text{AgCl}(\text{s})$
Ionic equation:
 $\text{Cl}^-(\text{aq}) + \text{Ag}^+(\text{aq}) \rightarrow \text{AgCl}(\text{s})$

- Q4. D** The definition of pH
 $\text{pH} = -\log_{10}[\text{H}_3\text{O}^+]$
 0.0100 M aqueous sodium hydroxide, NaOH.
 $[\text{OH}^-] = 0.0100 \text{ M}$
 The ionic product for water $K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1.0 \times 10^{-14} \text{ M}^2$
 $[\text{H}_3\text{O}^+](0.0100) = 1.0 \times 10^{-14}$
 $[\text{H}_3\text{O}^+] = (1.0 \times 10^{-14}) / (0.0100) = 1.0 \times 10^{-12} \text{ M}$
 $\text{pH} = -\log_{10}(1.0 \times 10^{-12}) = 12$
- Q5. C** The reaction between a metal oxide and an acid will produce water plus a solution of the salt of the metal.
 The sulfuric acid will provide H^+ ions that will react with the metal oxide.
 In this case the salt will be copper(II) sulfate.
 In an ionic equation **only the reacting materials are shown**.
 $\text{CuO}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
The question specifically asked for the ionic equation. Response B provides the full equation.
- Q6. B** The oxidant in a redox reaction is the material that causes oxidation to occur, therefore the oxidant will accept electrons and in the process is itself reduced.
For example, the oxidant in the reaction that occurs when a piece of zinc metal is placed in an aqueous solution of copper(II) sulfate is the copper(II) ion, $\text{Cu}^{2+}(\text{aq})$.
The half-equation for the reduction of the oxidant is
 $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$
The half-equation for the oxidation of the reductant is
 $\text{Zn}(\text{s}) \rightarrow \text{Zn}^{2+}(\text{aq}) + 2\text{e}^-$
The overall equation is
 $\text{Cu}^{2+}(\text{aq}) + \text{Zn}(\text{s}) \rightarrow \text{Cu}(\text{s}) + \text{Zn}^{2+}(\text{aq})$
- Q7. C** The conjugate base will be formed when the species acts as an acid.
 An acid is a proton, H^+ , donor.
 Therefore, the formula for conjugate base has had a proton, H^+ , removed.
 $\text{HCO}_3^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$
 For the hydrogen carbonate ion, the conjugate base is the carbonate ion, $\text{CO}_3^{2-}(\text{aq})$.
The hydrogen carbonate ion is an amphoteric ion. The conjugate acid for this ion is carbonic acid, $\text{H}_2\text{CO}_3(\text{aq})$.

- Q8. B** For a compound to be soluble in water, the water molecules need to form bonds with the materials in the compound. Since water is a polar molecule, then the compound needs to be either a polar molecule or an ionic substance. Water forms ion-dipole bonds with the ions in an ionic compound. Water forms hydrogen bonds and dipole-dipole interactions with polar compounds.
 Response A: The list contains the non-polar C₆H₆, benzene, which is not soluble in water. NaCl is an ionic compound. CH₃OH and CH₃COOH are polar molecules.
Response B: All four compounds are soluble because they are either polar molecules or ionic compounds.
 Response C: CH₄, C₈H₁₈ and CCl₄ are all non-polar.
 Response D: C₆H₁₄ is non-polar.
Remember: Like dissolves like.
- Q9. A** In this reaction the H⁺ ions are accepting an electron from the magnesium to form hydrogen gas, H₂. Therefore, the H⁺ ions are acting as the oxidant and will be reduced.

$$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$$
- Q10. D** The solubility for solids generally increases with temperature. More sugar will dissolve in hot water than in cold water. Only Response D fulfils this criterion.
- Q11. C** Mercury is a metal and in this case the concentration of mercury compounds in the water should be low. The most suitable technique would involve atomic absorption spectrophotometry.
 High performance liquid chromatography is more appropriate for organic contaminants of the water.
 Volumetric analysis is better suited to materials that are present in higher concentrations and can be involved in either acid-base or redox reactions.
 Gravimetric analysis involves weighing precipitates or solids from evaporated solutions, therefore is better suited to higher concentrations of materials.
- Q12. A** The solution is diluted by the factor of 10/250.
 For the solution:
 $c(\text{Na}_2\text{SO}_4) = 0.10 \times (10/250) = 0.0040 \text{ M}$
 Since each Na₂SO₄ contains one sulfate ion, SO₄²⁻, then
 $c(\text{SO}_4^{2-}) = 0.0040 \text{ M}$

- Q13. D** The concentration is given as a % (m/v) therefore in 100 mL there will be 17 g of the compound, NH_4OH .
 In 1.0 L there will be 170 g
 $M(\text{NH}_4\text{OH}) = 14.0 + 5 \times 1.0 + 16.0 = 35.0 \text{ g mol}^{-1}$
 $n(\text{NH}_4\text{OH}) = m/M = 170 / 35.0 = 4.9 \text{ mol}$
 $c(\text{NH}_4\text{OH}) = n/V = 4.9 / 1.0 = 4.9 \text{ mol L}^{-1}$ (or 4.9 M)
Alternative solution
 $17 \% \text{ NH}_4\text{OH} = 17 \text{ g in } 100 \text{ mL}$
 $n(\text{NH}_4\text{OH}) = 17 / 35.0 = 0.49 \text{ mol}$
 $c(\text{NH}_4\text{OH}) = n/V = 0.49 / (100/1000) = 4.9 \text{ mol L}^{-1}$
- Q14. C** The required percentage by mass is % m/m
 Since the first weighing of the solid is higher than the consecutive weighings this must still have contained water. This result is therefore not used.
 $m(\text{sea water}) = 137.594 - 35.094 = 102.50 \text{ g}$
 $m(\text{salts}) = 38.274 - 35.094 = 3.180 \text{ g}$
 $\% (\text{m/m}) = (3.180 / 102.50) \times (100/1) = 3.10 \% (\text{m/m})$
- Q15. B** The chemical equation for the reaction provides the mole ratio of the reactants
 $n(\text{NaHCO}_3) = c \times V = 0.1350 \times (20.00/1000) = 2.700 \times 10^{-3} \text{ mol}$
 $n(\text{H}_2\text{SO}_4) = \frac{1}{2} \times n(\text{NaHCO}_3) = \frac{1}{2} \times 2.700 \times 10^{-3} = 1.350 \times 10^{-3} \text{ mol}$
 $V(\text{H}_2\text{SO}_4) = n/c = 1.350 \times 10^{-3} / 0.1200 = 1.125 \times 10^{-2} \text{ L}$
 $V(\text{H}_2\text{SO}_4) = 1.125 \times 10^{-2} \times 1000 = 11.25 \text{ mL}$
- Q16. D** A strong acid completely ionises in water, therefore the hydrogen ion concentration is the same as that of the acid.
 A weak acid does not completely ionise in solution, therefore the hydrogen ion concentration will be lower than that of the acid.
 $\text{pH} = -\log_{10}[\text{H}^+]$
 Because of this relationship, the pH increases as the hydrogen ion concentration decreases.
 The pH of a weak acid solution will be higher than that of a strong acid with the same concentration.
Strong acid: 0.1 M HCl pH = 1.0
Weak acids: 0.1 M CH₃COOH pH = 2.9
0.1 M HCN pH = 5.1
HCN is a weaker acid than CH₃COOH.

- Q17. B** In a redox reaction there is a transfer of electrons from the reductant to the oxidant.
 Response A: The zinc is transferring electrons to the hydrogen ions when it is oxidised.
The oxidation numbers on zinc and hydrogen ions change from 0 to +2 and +1 to 0 respectively. Zinc is the reductant and the hydrogen ions are the oxidant.
Response B: No electrons are being transferred in this reaction, the ions are associating to form a precipitate.
The oxidation number on the iron remains at +2.
 Response C: The hydrogen is transferring electrons to the oxygen while being oxidised.
The oxidation numbers on hydrogen and oxygen change from 0 to +1 and 0 to -2 respectively. Hydrogen is the reductant and oxygen the oxidant.
 Response D: The copper is transferring electrons to the chlorine while being oxidised.
The oxidation numbers on copper and chlorine change from 0 to +2 and 0 to -1 respectively. Copper is the reductant and chlorine the oxidant.
- Q18. A** Because the beaker is open, the concentration of ammonia in the solution will decrease with time.
 This is readily experienced by the strong smell of ammonia from the vapours above the solution. Since the ammonia is in the vapour state, then the amount in solution must have decreased.
Domestic products now often have a date associated with labelled concentration.
- Q19. C** Sodium sulfate: Na_2SO_4
 $M(\text{Na}_2\text{SO}_4) = 2 \times 23.0 + 32.1 + 4 \times 16.0 = 142.1 \text{ g mol}^{-1}$
 $\text{Na}_2\text{SO}_4(\text{s}) \rightarrow 2\text{Na}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$
 $c(\text{Na}^+) = 0.025 \text{ M}$
 $n(\text{Na}^+) = c \times V = 0.025 \times 5.00 = 0.125 \text{ mol}$
 $n(\text{Na}_2\text{SO}_4) = \frac{1}{2} \times n(\text{Na}^+) = \frac{1}{2} \times 0.125 = 0.0625 \text{ mol}$
 $m(\text{Na}_2\text{SO}_4) = n \times M = 0.0625 \times 142.1 = 8.881 \text{ g}$
- Q20. A** Eutrophication is the condition that occurs as a result of an 'algal bloom' and their subsequent death. This results in a lowering of the level of dissolved oxygen in the water and the release of biotoxins. In these cases, there is a rapid growth of phytoplankton and this occurs because of increased levels of nutrients. The two main contributors to the nutrients are the nitrate and phosphate ions.

SECTION B – Short Answer (Answers)

Question 1 (4 marks)

- a. Full or ionic equations are acceptable.
The equations **must** show states to be awarded marks.
- i. All common Group 1 element compounds are soluble in water. The precipitate formed will be iron(III) hydroxide (**1 mark**).
$$\text{Fe}_2(\text{SO}_4)_3(\text{aq}) + 6\text{NaOH}(\text{aq}) \rightarrow 2\text{Fe}(\text{OH})_3(\text{s}) + 3\text{Na}_2\text{SO}_4(\text{aq})$$
$$\text{Fe}^{3+}(\text{aq}) + 3\text{OH}^{-}(\text{aq}) \rightarrow \text{Fe}(\text{OH})_3(\text{s})$$
- ii. All common nitrate compounds are soluble. The precipitate will be barium sulfate (**1 mark**).
$$\text{NiSO}_4(\text{aq}) + \text{Ba}(\text{NO}_3)_2(\text{aq}) \rightarrow \text{Ni}(\text{NO}_3)_2(\text{aq}) + \text{BaSO}_4(\text{s})$$
$$\text{SO}_4^{2-}(\text{aq}) + \text{Ba}^{2+}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$$
- b. i. The higher latent heat of vaporisation for water is due to the stronger interactions between the water molecules (**1 mark**).
Because methane is a non-polar molecule, only dispersion forces will occur between the methane molecules.
Water is a polar molecule and the stronger dipole-dipole interactions and hydrogen bonding will occur, in addition to dispersion forces, between the molecules.
As the forces of attraction between the water molecules are stronger, a larger amount of energy will be required to overcome these as water changes from a liquid into a gas.
- ii. The higher value for the latent heat of vaporisation for water, means that liquid water can be stored in open containers, whereas liquid methane would need to be stored in sealed containers to prevent evaporation (**1 mark**).

Question 2 (8 marks)

- a. i. The Brønsted-Lowry theory of acids and bases defines an acid as a proton donor and a base as a proton acceptor. An amphiprotic substance is one that can act as both an acid and a base (**1 mark**).
- ii. The hydrogen sulfite ion acting as an acid (**1 mark**).
$$\text{HSO}_3^{-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{SO}_3^{2-}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq})$$
$$\text{HSO}_3^{-}(\text{aq}) + \text{OH}^{-}(\text{aq}) \rightarrow \text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$$

The hydrogen sulfite ion acting as a base (**1 mark**).
$$\text{HSO}_3^{-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_2\text{SO}_3(\text{aq}) + \text{OH}^{-}(\text{aq})$$
$$\text{HSO}_3^{-}(\text{aq}) + \text{H}_3\text{O}^{+}(\text{aq}) \rightarrow \text{H}_2\text{SO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
$$\text{HSO}_3^{-}(\text{aq}) + \text{H}^{+}(\text{aq}) \rightarrow \text{H}_2\text{SO}_3(\text{aq})$$

- b.** A strong acid is one that **completely ionises in solution**, liberating protons (**1 mark**).
A concentrated acid refers to a **larger amount of the acidic material in solution**. (**1 mark**).

Hydrochloric acid is a strong acid whereas ethanoic acid is a weak acid.

Pure ethanoic acid, which is a liquid, is a concentrated acid (approximately 17 M), but ethanoic acid is a weak acid.

The pH of 0.10 M aqueous solutions of hydrochloric and ethanoic acids are 1.0 and 2.9 respectively. Aqueous solutions of weak acids have a higher pH than aqueous solutions of strong acids with the same concentration.

- c.** Referring to the VCE Chemistry Data Book: Table 3
Ionic product for water: $[\text{H}_3\text{O}^+][\text{OH}^-] = 1.00 \times 10^{-14} \text{ M}^2$
 $\text{pH} = 7.5$

$[\text{H}_3\text{O}^+] = 10^{-\text{pH}} = 10^{-7.5} = \mathbf{3.2 \times 10^{-8} \text{ M}}$ (**1 mark**).

$[\text{OH}^-] = 1.00 \times 10^{-14} / [\text{H}_3\text{O}^+] = 1.00 \times 10^{-14} / 3.2 \times 10^{-8} = \mathbf{3.2 \times 10^{-7} \text{ M}}$ (**1 mark**).

- d.** When acids react with carbonates, carbon dioxide, water and an aqueous solution of the metal ion salt are formed (**1 mark**).

Appropriate states must be shown to be awarded mark.

Full or ionic equations would be acceptable.

Full equation: $\text{CaCO}_3(\text{s}) + 2\text{HNO}_3(\text{aq}) \rightarrow \text{Ca}(\text{NO}_3)_2(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

Ionic equation: $\text{CaCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$

$\text{CaCO}_3(\text{s}) + 2\text{H}_3\text{O}^+(\text{aq}) \rightarrow \text{Ca}^{2+}(\text{aq}) + \text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$

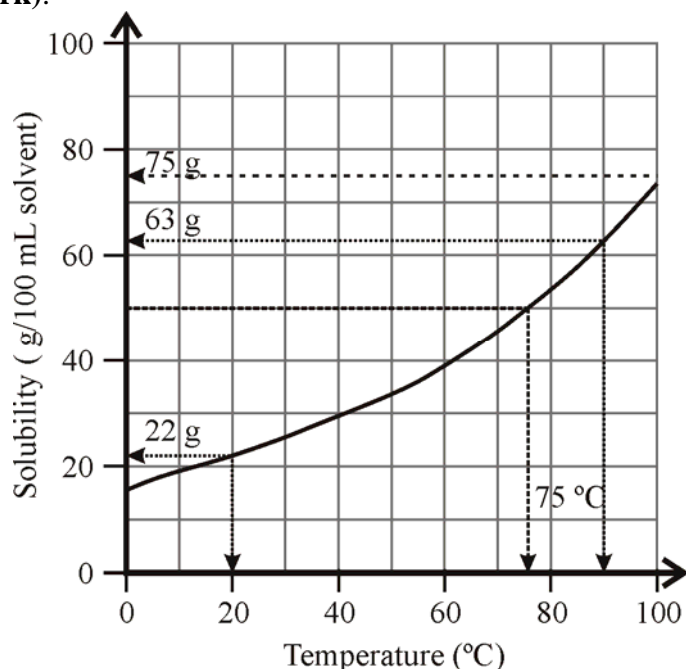
Question 3 (9 marks)

- a. i.** Oxidation is the loss of electrons and reduction is the gain of electrons. The oxidant causes the oxidation reaction to occur, therefore the oxidant will accept electrons and be reduced. Similarly the reductant causes the reduction reaction to occur, therefore the reductant will lose electrons and be oxidised.
The oxidants in this experiment are the metal ions, therefore the strongest oxidant will be the metal ion that reacts with all of the other metals. In this case it will be **$\text{Y}^+(\text{aq})$** (**1 mark**).
The reductants will be the metals, the strongest reductant will react with all of the other metal ion solutions. In this case **X** (**1 mark**).
- ii.** Oxidation involves the loss of electrons.
Oxidation half-equation: $\text{Z}(\text{s}) \rightarrow \text{Z}^{2+}(\text{aq}) + 2\text{e}^-$ (**1 mark**).
Reduction half-equation: $\text{Y}^+(\text{aq}) + \text{e}^- \rightarrow \text{Y}(\text{s})$ (**1 mark**).
- iii.** The overall equation is obtained by adding the two half-equations adjusting each so that the number of electrons produced and consumed is the same. Since two electrons are released in the oxidation half-reaction and one electron is consumed in the reduction half-reaction, when adding the two half-equations, the reduction half-equation must be multiplied by 2
 $(\text{Y}^+(\text{aq}) + \text{e}^- \rightarrow \text{Y}(\text{s})) \times 2$
 $2\text{Y}^+(\text{aq}) + 2\text{e}^- \rightarrow 2\text{Y}(\text{s})$
 $\text{Z}(\text{s}) \rightarrow \text{Z}^{2+}(\text{aq}) + 2\text{e}^-$
 $2\text{Y}^+(\text{aq}) + \text{Z}(\text{s}) \rightarrow 2\text{Y}(\text{s}) + \text{Z}^{2+}(\text{aq})$ (**1 mark**).

- b.**
- i.** Tin is a weaker reductant than iron, therefore will be less reactive. The tin forms a protective coating on the surface of the steel preventing its oxidation **(1 mark)**.
 - ii.** Once the surface coating is broken, the iron in the steel, will be oxidised in preference to the tin and the can will rust **(1 mark)**.
 - iii.** Zinc is more reactive than iron therefore will corrode in preference to the steel. This is known as sacrificial protection **(1 mark)**. When the zinc is oxidised, it becomes coated with a thin layer of material which protects the surface from further oxidation. If this surface layer of oxidised material is damaged, a new layer will form until all of the zinc coating has been consumed.
 - iv.** Zinc is not used as a coating on food cans because zinc compounds are toxic **(1 mark)**.

Question 4 (5 marks)

- a.** Solubility is expressed in terms of mass of solute dissolved in 100 mL of solvent. The mass of solute in 100 mL of solvent would be
 $m = 10.0 \times (100/20.0) = 50.0 \text{ g}$
 Using the solubility curve as shown below, this would require the mixture be heated to **75 °C (1 mark)**.

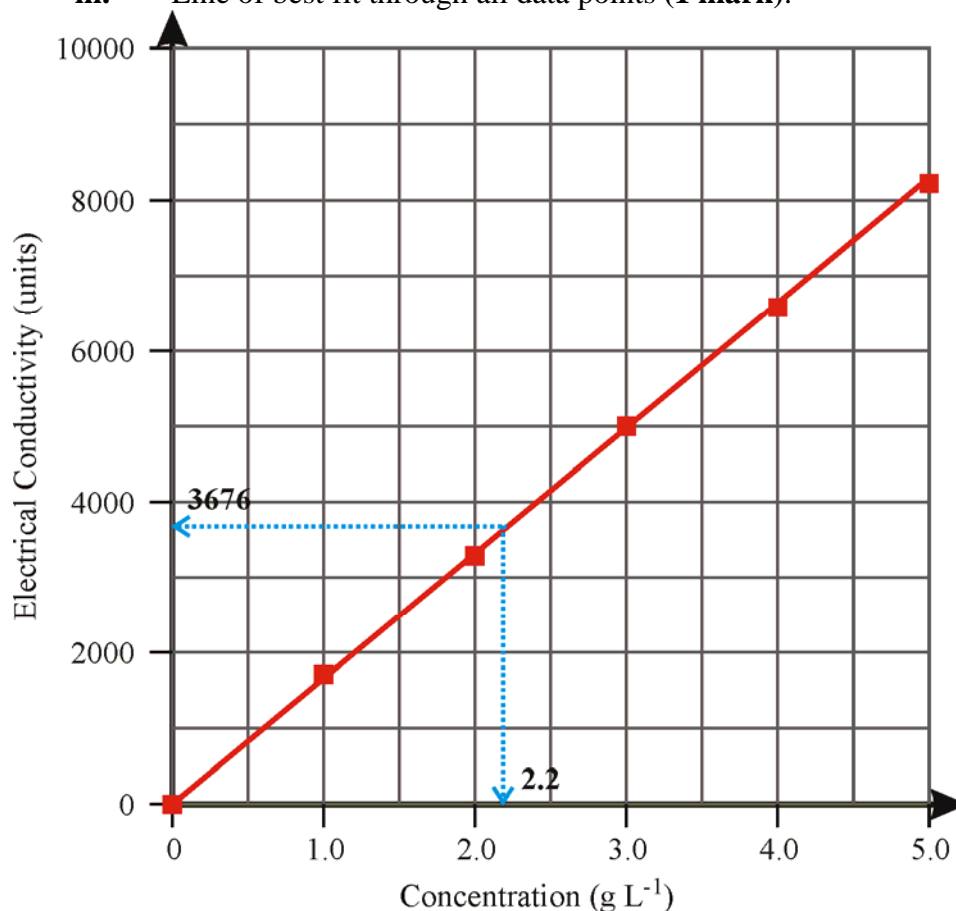


- b.** From the solubility curve data, the solubilities at 20 °C and 90 °C are 22 g/100 mL and 63 g/100 mL respectively. Therefore, the mass of solid that should crystallise when 100 mL of a saturated solution is cooled over the temperature range will be
 $m = 63 - 22 = 41 \text{ g (1 mark)}$.
 For 250 mL of solution
 $m = 41 \times (250/100) = 103 \text{ g (1 mark)}$.

- c. $M(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = 249.6 \text{ g mol}^{-1}$
 $c = 3.0 \text{ M} = 3.0 \text{ mol L}^{-1}$
 Therefore, in 100 mL
 $n(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = c \times V = 3 \times (100/1000) = 0.3 \text{ mol}$
 $m(\text{CuSO}_4 \cdot 5\text{H}_2\text{O}) = n \times M = 0.3 \times 249.6 = 75 \text{ g}$ (1 mark).
 From the solubility curve it can be seen that this mass is greater than the solubility at 100 °C. Therefore, a 3.0 M solution could not be prepared (1 mark).

Question 5 (6 marks)

- a. Calibration curve graph should have:
- Correctly labelled axes (1 mark).
 - Correctly plotted data (1 mark).
 - Line of best fit through all data points (1 mark).



- b. From the calibration curve, an electrical conductivity of 3676 units corresponds to a sodium chloride concentration of **2.2 g L⁻¹** (1 mark).
- c. All the glassware was thoroughly rinsed with deionised water prior to commencing to ensure that any soluble materials were removed, thereby preventing these from contributing to the measurements and providing higher electrical conductivity results (1 mark).

- d.** Answers could include: **[(1 mark) for an appropriate answer]**
Solids dissolved in the run-off from either agricultural or urban land.
If the creek was near the coast, salt water coming from the sea as a result of back flow into the creek from the sea, due to either low flow rates of fresh water down the creek or storm surges pushing salty sea water up the creek.
Dissolution of solids from the soil in the creek bed.
Waste materials containing ionic compounds entering the stream either accidentally or deliberately.
In northern hemisphere countries, the dissolved salts in creek water could be due to run off following snow, as salt is used in road de-icing processes.
Note: The answer, 'pollution' would not be considered to be an acceptable answer.

Question 6 (6 marks)

- a.**
- i.** Suitable answers could include, but are not limited to:
[Mark allocation: 1 mark for a suitable answer. Total 2 marks]
Insecticide residues that have been washed from the land or sprayed over water sources.
Pesticides that have been used to kill weeds being washed into waterways.
Oil spills, either during transport or at filling facilities (including petrol stations).
Materials that have been used domestically that have not broken down, this could include hand sanitiser materials or compounds used in shampoos.
Leakage of organic materials from industrial storage areas.
Non-biodegradable detergents.
Antibiotics from either human or animal waste.
Dioxins.
- ii.** The answer must link the selected organic material to a plausible environmental impact **(1 mark)**.
Example: Pesticides – The residues being concentrated in an animal higher up the food chain eating consumers and having an effect on that animal.
- b.**
- i.** The peak due to caffeine could be identified by running a chromatograph using an aqueous solution of caffeine under the same conditions. Then using the retention time for the caffeine to identify a peak with the same retention time in the tea solution **(1 mark)**.
- ii.** It would first be necessary to construct a calibration curve using solutions with known concentrations. The calibration curve is constructed by plotting the concentration versus the area under the peak, or less accurately the peak height **(1 mark)**.
The area under the peak, or peak height, is then used to determine the concentration from the calibration curve **(1 mark)**.

Question 7 (7 marks)

- a. The aliquots are 10.00 mL of 0.100 M aqueous sodium carbonate.
 $n(\text{Na}_2\text{CO}_3) = c \times V = 0.100 \times (10.00/1000) = \mathbf{1.00 \times 10^{-3} \text{ mol (1 mark)}}$.
- b. The stoichiometry of the reaction is given by the chemical equation
$$2\text{CH}_3\text{COOH}(\text{aq}) + \text{Na}_2\text{CO}_3(\text{aq}) \rightarrow 2\text{NaCH}_3\text{COO}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$$

 $n(\text{CH}_3\text{COOH}) = 2 \times n(\text{Na}_2\text{CO}_3) = 2 \times 1.00 \times 10^{-3} = \mathbf{2.00 \times 10^{-3} \text{ mol (1 mark)}}$.
- c. $c(\text{CH}_3\text{COOH}) = n/V = (2.00 \times 10^{-3}) / (11.50/1000) = \mathbf{1.74 \times 10^{-1} \text{ M (0.174 M) (1 mark)}}$.
- d. The diluted vinegar solution was prepared by diluting a 20.00 mL sample with deionised water to 250.0 mL. In the original sample
 $c(\text{CH}_3\text{COOH}) = (1.74 \times 10^{-1}) \times (250.0/20.0) = \mathbf{2.17 \text{ M (1 mark)}}$.
- e. The amount of ethanoic acid in 1.00 L (1000 mL) of solution can be determined
 $M(\text{CH}_3\text{COOH}) = 2 \times 12.0 + 4 \times 1.0 + 2 \times 16.0 = 60.0 \text{ g mol}^{-1}$
 $m(\text{CH}_3\text{COOH}) = n \times M = 2.17 \times 60.0 = 130 \text{ g (1 mark)}$.
 $\%(\text{CH}_3\text{COOH}) = (130/1000) \times (100/1) = 13.0 \% \text{ (m/v) (1 mark)}$.
This value is slightly higher than the manufacturer's claim of 12.5 % (m/v). The higher concentration may have been the result of evaporation of water from the vinegar
(1 mark).
The boiling point of ethanoic acid is 118 °C which is higher than water. The water would therefore evaporate faster than the ethanoic acid and the concentration would increase.

Question 8 (5 marks)

- a. $M(\text{HCl}) = 1.0 + 35.5 = 36.5 \text{ g mol}^{-1}$
The mass of HCl in 100 mL (110.8 g solution)
 $m(\text{HCl}) = 110.8 \times (22/100) = 24.4 \text{ g}$
 $n(\text{HCl}) = m/M = 24.4 / 36.5 = 0.67 \text{ mol}$ (1 mark).
 $c(\text{HCl}) = n/V = 0.67 / (100/1000) = 6.7 \text{ mol L}^{-1} = \mathbf{6.7 \text{ M}}$ (1 mark).

Alternative solution:

22 % (m/m) = 22 g HCl in 100 g of solution

In 100 g of solution

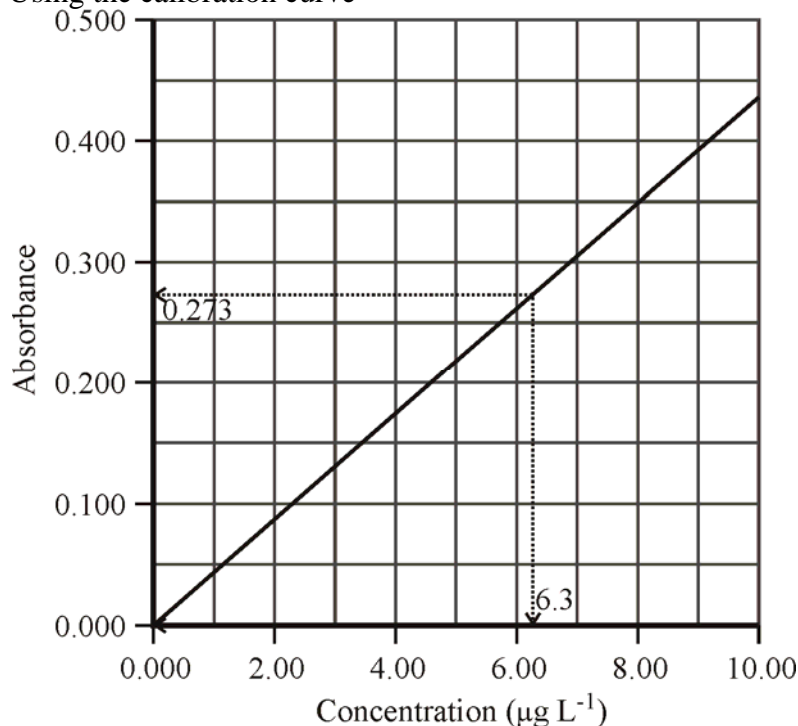
$n(\text{HCl}) = m/M = 22.0 / 36.5 = 0.603 \text{ mol}$

The volume of 100 g of solution will be

$V = 100/(110.8/100) = 90.5 \text{ mL}$

$c(\text{HCl}) = n/V = 0.603 / (90.5/1000) = 6.7 \text{ mol L}^{-1} = \mathbf{6.7 \text{ M}}$

- b. i. Using the calibration curve



- Concentration of arsenic = $\mathbf{6.3 \mu\text{g L}^{-1}}$ (1 mark).
- ii. Convert the concentration to ppb = g per 10^9 g
In 1.0 L of water $6.3 \mu\text{g As} = 6.3 \times 10^{-6} \text{ g}$
 $1.0 \text{ L water} = 1.0 \text{ kg} = 1.0 \times 10^3 \text{ g}$
 $c(\text{As}) = 6.3 \times 10^{-6} \text{ g in } 1.0 \times 10^3 \text{ g}$
Multiply both values by 10^6
 $c(\text{As}) = 6.3 \text{ g in } 1.0 \times 10^9 \text{ g} = 6.3 \text{ ppb}$
Since this is below WHO minimum value, it meets the requirement. (1 mark).
- iii. This water supply could pose a problem if it were used for agricultural purposes as the arsenic present could be accumulated in the plants to such a level that it could cause health problems when the plant is consumed (1 mark).

End of Suggested Answers