

Trial Examination 2018

VCE Chemistry Unit 2

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

1	☐ A	☐ B	☐ C	☒ D
2	☐ A	☐ B	☒ C	☐ D
3	☐ A	☐ B	☐ C	☒ D
4	☐ A	☐ B	☒ C	☐ D
5	☒ A	☐ B	☐ C	☐ D
6	☐ A	☐ B	☒ C	☐ D
7	☐ A	☐ B	☒ C	☐ D
8	☐ A	☒ B	☐ C	☐ D
9	☒ A	☐ B	☐ C	☐ D
10	☐ A	☐ B	☐ C	☒ D

11	☐ A	☐ B	☐ C	☒ D
12	☐ A	☒ B	☐ C	☐ D
13	☐ A	☐ B	☒ C	☐ D
14	☒ A	☐ B	☐ C	☐ D
15	☐ A	☒ B	☐ C	☐ D
16	☐ A	☒ B	☐ C	☐ D
17	☐ A	☐ B	☐ C	☒ D
18	☒ A	☐ B	☐ C	☐ D
19	☐ A	☒ B	☐ C	☐ D
20	☒ A	☐ B	☐ C	☐ D

Question 1 D

A conjugate redox pair is two related chemical species which differ only in their number of electrons. **A** and **C** are conjugate acid–base pairs as each of the two species differ by a H^+ .

Question 2 C

$n(\text{HCl})$ in excess = $0.10 \times 0.020 = 2.0 \times 10^{-3}$ mol in a total volume of 100 mL

$$c(\text{HCl}) = \frac{n}{V} = \frac{2.0 \times 10^{-3}}{0.1} = 0.020 \text{ M}$$

$[\text{H}_3\text{O}^+] = 0.020 \text{ M}$ (as HCl is a strong acid)

Question 3 D

Acids will react with metal carbonates to give a metal salt, carbon dioxide gas and water. **I** is correct. Acids will react with reactive metals to give a metal salt and hydrogen gas. **II** is also correct. Most aquatic life requires water at a neutral pH to function normally and so lowering the pH of the water will cause damage. **III** is also correct.

Question 4 C

$[\text{H}_3\text{O}^+]$ in citric acid = $0.08 \times 0.10 = 0.008 \text{ M} = 10^{-2.1} \text{ M}$

$$\text{pH} = -\log_{10} 10^{-2.1} = 2.1$$

Question 5 A

As each acid has a different degree of ionisation, the number of ions present will differ and thus each electrical conductivity will be different. Method **I** could be used to distinguish between the acids. Similarly, using different indicators which change colour at various pH values will allow the acids to be identified because each acid has a particular hydrogen ion concentration resulting from the different degree of ionisation. Method **II** could be used. As each acid has the same concentration, a set volume of each acid will require the same number of mole of a base to be neutralised. Method **III** could not be used to distinguish between the acids.

Question 6 C

Ethanoic acid is a weak acid as it ionises to a small extent. Its concentration of 0.10 M shows that it is a dilute solution. The nitric acid solution is also dilute. Nitric acid is a strong acid as it fully ionises.

Question 7 C

$$c_1 V_1 = c_2 V_2$$

$$0.546 \times 75 = 0.164 \times V_2$$

$$V_2 = 249.7 \text{ mL} \approx 250 \text{ mL}$$

volume of water added = $250 - 75 = 175 \text{ mL}$

Question 8 B

The group 16 hydride with the lowest relative molecular mass is H_2O , which changes from solid to liquid at 0°C .

Question 9 A

All group 16 hydrides are polar molecules and a significant intermolecular interaction is dipole-dipole attraction. Dispersion forces are also present. Covalent bonding is an intramolecular force and so **B** is not correct. Only water molecules are capable of forming the strongest type of intermolecular attraction, hydrogen bonding. Hydrogen bonding does not form between the other hydride molecules, so **D** is incorrect.

The extent of the dipole in the molecules would decrease moving down the group, as electronegativity decreases down the group. With decreasing dipole extent, the strength of dipole-dipole bonding would decrease, and so the melting points would decrease. This is not the observed trend. Dispersion force strength would increase moving down the group as the group 16 atoms become larger. With increasing dispersion force strength, increasing melting points would be expected. This is the observed trend, so **A**, not **C**, is the required answer.

Question 10 D

The values for the latent heat of vaporisation of compounds are related to the strength of forces between the molecules. Covalent bonds are forces within molecules and will have no impact on the latent heat values.

A is not correct. **B** and **C** are correct statements of fact but neither phenomenon has any influence on the latent heat values. **D** correctly explains that the intermolecular bonding in water (that is, hydrogen bonding) is stronger than for methane (that is, dispersion forces), and so water should have a higher latent heat value as more energy is required to overcome attraction between the molecules to effect vaporisation. **D** is the required answer.

Question 11 D

As the pH of the sulfuric acid solution is 1.0, $[\text{H}_3\text{O}^+] = 10^{-1.0}$ M. However, H_2SO_4 is a diprotic, strong acid, so if its concentration was 0.10 mol L^{-1} , $[\text{H}_3\text{O}^+]$ would be greater than 0.10 M. **A** is not correct. In Na_2SO_4 solution, $[\text{H}_3\text{O}^+] = 10^{-7.0}$ M, and for NaHSO_4 solution, $[\text{H}_3\text{O}^+] = 10^{-3.0}$ M. The acidity of NaHSO_4 solution is greater than the acidity of Na_2SO_4 solution and so **B** is incorrect. Adding water to a volume of sulfuric acid will decrease the concentration of the hydrogen ion and so increase the pH. **C** is also incorrect. In a neutral solution at 25°C the pH is 7.0, so $[\text{H}_3\text{O}^+] = [\text{OH}^-] = 10^{-7.0}$ M. **D** is the required answer.

Question 12 B

The HSO_4^- ion is amphiprotic; thus it will react with a strong acid as a base, and will react with a strong base as an acid.

Question 13 C

$$n(\text{Na}_2\text{CO}_3) = c \times V = 0.612 \times 0.250 = 0.153 \text{ mol}$$

$$m(\text{Na}_2\text{CO}_3) = n \times M = 0.153 \times [(2 \times 23) + 12 + (3 \times 16)] = 16.2 \text{ g}$$

Question 14 A

Oxidation is the loss of electrons. When a non-metal ion – an anion – becomes a gaseous molecule, electrons are released, as shown in the half equation $2\text{Cl}^-(\text{aq}) \rightarrow \text{Cl}_2(\text{g}) + 2\text{e}^-$. **A** is the required answer. When a metal ion – a cation – becomes an atom, electrons are gained, as shown in the half equation $\text{Na}^+(\text{l}) + \text{e}^- \rightarrow \text{Na}(\text{s})$.

C describes reduction, not oxidation. Precipitation and the change of state from liquid to gas do not involve movement of electrons, and these are not redox processes. **B** and **D** are incorrect.

Question 15 B

As each compound in the water sample has a different structure, there will be a different interaction with the solvent and the stationary phase, allowing separation of the mixture to occur. **A** is correct. The component moving through the column at the fastest rate will have the lowest retention time because it is least strongly attracted to the stationary phase. **C** is also correct. The concentration of a component is given by the area under the peak and so component R is at the lowest concentration. **D** is correct. Lowering the temperature will slow the adsorption–desorption process of all components and thus will increase retention times. **B** is incorrect and so is the required answer.

Question 16 B

Peak S has been identified as a particular pesticide with a concentration of 20 ppm. On the HPLC analysis of the second farm there is also a small peak at the retention time of 4.0 minutes. This small peak has an **area** which is less than one-third of the area of peak S. As the HPLC analyses were conducted under identical conditions on the same column, the concentration of the pesticide in the water sample of farm 2 is less than one-third of 20 ppm, and so **B** is the required response.

Question 17 D

75% of fresh water is found in the glaciers and ice caps.

Question 18 A

$c(\text{Cl}_2) = \frac{m}{V} = \frac{1.0}{250\,000} = 4.0 \times 10^{-6} \text{ g L}^{-1}$; thus the value in **B** is correct.

% m/V of $\text{Cl}_2 = 4.0 \times 10^{-6} \text{ g L}^{-1} = 0.40 \times 10^{-6} \text{ g per 100 mL} = 4.0 \times 10^{-7} \text{ g per 100 g}$ (assuming the density of water is 1 g mL^{-1}); alternative **A** is thus incorrect and so is the required answer.

$c(\text{Cl}_2) = \frac{n}{V} = \frac{m}{M \times V} = \frac{\frac{1.0}{71}}{250\,000} = 5.6 \times 10^{-8} \text{ M}$; thus the value in **C** is correct.

$c(\text{Cl}_2) = 4.0 \times 10^{-6} \text{ g L}^{-1} = 4.0 \times 10^{-6} \times 10^3 \text{ mg L}^{-1} = 4.0 \times 10^{-3} \text{ ppm}$; thus the value in **D** is correct.

Question 19 B

By referring to the electrochemical series we see that Cu^{2+} ions will react with Pb, while Zn^{2+} ions will not. The reaction will be $\text{Pb(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Pb}^{2+}(\text{aq}) + \text{Cu(s)}$. **A**, **B** and **C** show correct, expected observations. **B** is incorrect, and so is the required response.

Question 20 A

Non-polar gases such as methane have very low solubility in water as the intermolecular bonding consists of dispersion forces only, and so the stronger hydrogen bonding between water molecules is not easily disrupted. Unlike solids, increasing the temperature of the water lowers the solubility of the gases.

SECTION B

Question 1 (13 marks)

- a. $4\text{Al(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Al}_2\text{O}_3\text{(s)}$ 2 marks

*1 mark for correct reactants and products.
1 mark for correct balancing and state symbols.*

- b. $\text{Y} > \text{Al} > \text{X} > \text{Z}$ 2 marks
(a more reactive metal will undergo a displacement reaction with ions of a less reactive metal)

Note: Award 1 mark if three of the metals are in the correct order.

- c. i. $2\text{Al(s)} + 6\text{H}^+\text{(aq)} \rightarrow 2\text{Al}^{3+}\text{(aq)} + 3\text{H}_2\text{(g)}$ 2 marks

*1 mark for correct reactants and products.
1 mark for correct balancing and state symbols.*

- ii. $\text{Al(s)} \rightarrow \text{Al}^{3+}\text{(aq)} + 3\text{e}^-$ 1 mark

- iii. Both experiments should produce bubbling as hydrogen gas evolves. HCl will produce bubbling at a faster rate than HCOOH. 1 mark

- d. i. Hydroxide ions accept protons readily. 1 mark

- ii. $n(\text{HCl}) = c \times V = 0.135 \times 0.01465 = 1.977 \times 10^{-3} \text{ mol}$ 1 mark

$$n(\text{NaOH}) = n(\text{HCl}) \quad 1 \text{ mark}$$

$$c(\text{NaOH}) = \frac{n}{V} = \frac{1.977 \times 10^{-3}}{0.02000} = 0.09888 = 0.0989 \text{ mol L}^{-1} \quad 1 \text{ mark}$$

- iii. when the indicator changes colour (at a particular pH) to show that the reaction is complete 1 mark

Question 2 (13 marks)

- a. i. a chemical substance which does not naturally occur in the particular environment, or is present in such concentrations that it is likely to harm the environment or any living things in that environment 1 mark

- ii. *For example, any two of the following:*

- The sample must be representative of the body of water; this is done by taking it from different depths and locations within the water.
- Samples should be stored so that their condition does not change during transport.
- Clean and sterile containers which can be sealed tightly must be used.
- Health and safety guidelines must be observed throughout the sampling procedure.

2 marks

Note: Other important steps in a water-sampling protocol can also be given.

b. *For example:*

The concentration of dissolved oxygen in water decreases with an increase in temperature. 1 mark

Heated waste water released from industries into the river system could be the cause of the low dissolved oxygen content. 1 mark

c. i. 17.5 or 18 ppm 1 mark

ii. It is likely that the orchard uses chemicals (for example, fertilisers) which contain phosphates and the run-off water ends up in the river system. 1 mark

iii. The graph cannot be extrapolated so that there is a corresponding phosphate ion value for the absorbance of 0.70 as there is no certainty for the shape of the graph. 1 mark

Dilute the water sample so that there is a corresponding value and account for the dilution when calculating the phosphate ion concentration. 1 mark

OR

Construct another calibration graph which does have a phosphate ion concentration which corresponds to the absorbance of 0.70. 1 mark

d. Compound I would be water-soluble due to its small size and ability to form hydrogen bonds with water molecules via the OH groups. 1 mark

Compound II would not be water-soluble as it is a large, essentially non-polar molecule which has little ability to bond to highly polar water molecules. 1 mark

e. The phosphate ion complex is blue, which indicates that the solution absorbs wavelengths of light from the red end of the spectrum. The orange–yellow complex used to measure iron content absorbs wavelengths of light from the blue end of the spectrum and so a different wavelength of light must be used. 1 mark

f. atomic absorption spectrometer 1 mark

Question 3 (16 marks)

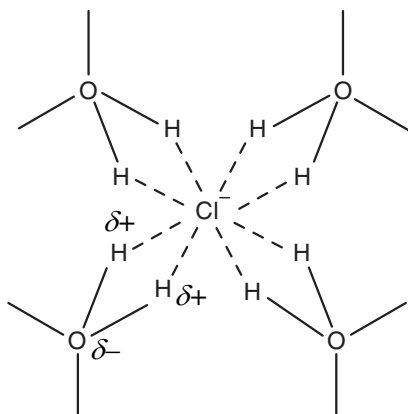
a. i. $n(\text{KCl}) = \frac{m}{M} = \frac{57}{39.1 + 35.5} = 0.764 \text{ mol}$ 1 mark

$c(\text{KCl}) = \frac{n}{V} = \frac{0.764}{0.100} = 7.64 \text{ M} = 7.7 \text{ M}$ 1 mark

ii. **Dissociation:** KCl is composed of K^+ ions and Cl^- ions and these separate when the solid dissolves to produce a solution of ions. 1 mark

Ionisation: HCl is composed of uncharged molecules. These react with water molecules to generate the ions H_3O^+ and Cl^- . 1 mark

iii.



2 marks

*1 mark for correct orientation of water molecules around Cl⁻ ion.**1 mark for correct naming of the ion-dipole bond.*

The polar water molecules orientate so that the positive end of the molecule attracts the negative chloride ions using ion-dipole bonding.

1 mark

- b.** Make solutions of KCl of different concentrations and read the electrical conductivity of each solution. 1 mark
- Construct a graph of conductivity against concentration of KCl. 1 mark
- Read the electrical conductivity of the KCl solution under analysis and use the graph to determine the corresponding concentration of KCl. 1 mark
- c.**
- i.** 10.0 mL of pure water = 10 g, and change in temperature = 65°C
energy used = $m \times c \times \Delta T = 10 \times 4.18 \times 65 = 2717 \text{ J} = 2.7 \times 10^3 \text{ J}$ 1 mark
- ii.** saturated solution 1 mark
- iii.** At 59°C there is 4.0 g in 18.0 mL (or grams) of water. 1 mark
- solubility = $\frac{100 \times 4.0}{18.0} = 22.2 = 22 \text{ g per 100 g water}$ 1 mark
- d.** There is only a small difference in the solubility of NaCl in the range from 0°C to 50°C. 1 mark
- As the method relies on detecting when crystals first appear at a particular temperature, it would be difficult to judge this so precisely so that the small differences in solubility are measured. 1 mark

Question 4 (8 marks)

- a.**
- i.** $\text{SO}_4^{2-}(\text{aq}) + \text{Ba}^{2+}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$ 1 mark
- ii.** Mg^{2+} or Cl^- 1 mark
- b.**
- i.** Any insoluble material had to be removed; otherwise it would have been trapped in the precipitate in step 3 and would have resulted in an inaccurate mass of the precipitate being recorded. 1 mark
- ii.** $n(\text{BaSO}_4) = \frac{m}{M} = \frac{3.54}{137.3 + 32.1 + 64.0} = 0.01516 = 0.0152 \text{ mol}$ 1 mark

iii. $n(\text{SO}_4^{2-}) = n(\text{BaSO}_4)$

$$m(\text{SO}_4^{2-}) = n \times M = 0.01516 \times 96.1 = 1.456 \text{ g} = 1.46 \text{ g} \quad 1 \text{ mark}$$

iv. $\% \text{ by mass} = \frac{\text{mass of } \text{SO}_4^{2-}}{\text{mass of fertiliser}} \times \frac{100}{1} = \frac{1.46}{2.00} \times \frac{100}{1} = 73.0\% \quad 1 \text{ mark}$

c. *For example:*

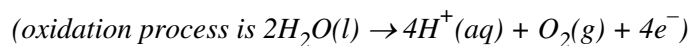
No other ions present would precipitate with barium ions. 1 mark

d. *For example:*

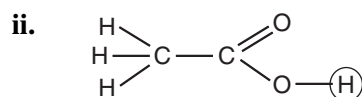
The experiment should be repeated numerous times and an average of the final percentage calculated. 1 mark

Question 5 (5 marks)

a. reducing agent 1 mark



b. i. $\text{C}_2\text{H}_6\text{O}(aq) + \text{H}_2\text{O}(l) \rightarrow \text{C}_2\text{H}_4\text{O}_2(aq) + 4\text{H}^+(aq) + 4e^- \quad 1 \text{ mark}$



1 mark

iii.

Glassware	Liquid used for final rinse prior to use
100.0 mL volumetric flask	distilled water
50.0 mL burette	acidified MnO_4^- solution

2 marks