Neap

Trial Examination 2021

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 A

A is correct. General reactions involving an acid include the following.

metal + acid → salt + hydrogen **gas**

metal carbonate + acid → salt + water + carbon dioxide **gas**

B, **C** and **D** are incorrect.

metal hydroxide + acid → salt + water (no gas produced)

Question 2 D

D is correct. Sodium chloride is an ionic compound and dissolves in water by the individual ions being surrounded by water molecules. This involves ion–dipole attraction between the ions and water molecules. There are covalent bonds within the water molecules, and there are also hydrogen bonds and dispersion forces between the water molecules.

Question 3 B

B is correct. Water has a high specific heat capacity. This means that it can absorb a large amount of energy and slowly increase in temperature, without readily boiling. This allows it to act as a coolant in the car radiator. **A** and **C** are incorrect. Solvent properties and expansion on freezing relate to the polarity of water and its ability to form hydrogen bonds. **D** is incorrect. Evaporative cooling relates to the high latent heat of vaporisation of water (absorption of heat as water turns from liquid to gas).

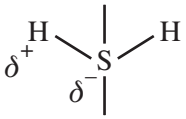
Question 4 B

$$n\left(\mathrm{KNO_3}\right) = \frac{m}{M} = \frac{2.00}{101.1} = 0.01978 \text{ mol}$$

$$c\left(\mathrm{KNO_3}\right) = \frac{n}{V} = \frac{0.01978}{0.350} = 0.0565 \text{ M}$$

Question 5 B

B is correct. The group 16 hydrides shown are V-shaped molecules. They are polar due to differences in the electronegativity of hydrogen and each group 16 element, and the asymmetric nature of the molecules. For example:



Question 6 C

C is correct. The hydride of group 16 with the lowest molar mass is water, which has 10 electrons per molecule (that is, eight in the oxygen atom and one in each hydrogen atom).

Question 7 C

C is correct, and **A** and **B** are incorrect. Water has hydrogen bonding between its molecules and so has a much higher boiling point than the other hydrides shown. It does not follow the trend. **D** is incorrect. The boiling point is an indication of the strength of the bonds between molecules and is not directly related to the bonds within each molecule.

Question 8 A

A is correct. An amphiprotic species can donate a proton or accept a proton. For example:

- $HCO_3^-(aq) + OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$ when $HCO_3^-(aq)$ acts as an acid
- $HCO_3^-(aq) + H_3O^+(aq) \rightarrow H_2CO_3(aq) + H_2O(l)$ when $HCO_3^-(aq)$ acts as a base

B is incorrect. S^{2-} cannot donate a proton. **C** is incorrect. H_3O^+ cannot accept a proton. **D** is incorrect. H_2SO_4 is a diprotic acid, but it cannot accept a proton.

Question 9 B

B is correct. There are a number of ways to demonstrate that H_2S is an acidic gas. Two simple techniques are to bubble the gas through a solution of an indicator or use moist litmus paper. **A** is incorrect. An acid–base titration could be used with a solution of H_2S dissolved in water, but is a much more complicated process. **C** and **D** are incorrect. Colorimetry or measuring conductivity could not be used in a simple manner to show the acidity of H_2S gas.

Question 10 A

A is correct and **B** and **C** are incorrect. The method in the flow chart relies on all of the H_2S gas being converted to a precipitate. Excess $AgNO_3$ will ensure this occurs. If some gas were to remain unreacted, the precipitate mass will be lower and the estimation of the purity of the solid will be incorrect. **D** is incorrect. Careful filtration in step 3 will ensure that very little precipitate is lost.

Question 11 C

C is correct and **A** is incorrect. Washing is used in gravimetric analysis to ensure that only the precipitate is retained and any other soluble material present is removed. **B** is incorrect. The unreacted acid in step 1 will not be present in step 3 because the gas evolved from the reaction was converted into a precipitate in step 2. **D** is incorrect. Washing with water cannot remove insoluble material.

Question 12 A

$$n(\text{FeS}) = n(\text{H}_2\text{S}) = n(\text{Ag}_2\text{S}) = \frac{m}{M} = \frac{8.581}{247.9} \text{ mol}$$

$$m(\text{FeS}) = n \times M = \frac{8.581}{247.9} \times 87.9 = 3.043 \text{ g}$$

$$\% \text{ purity} = \frac{3.043}{3.112} \times 100 = 97.8\%$$

Thus impurities in the solid in step 1 were 2.2%.

Question 13 D

D is correct. The solubility is quite high at low temperatures but decreases at high temperatures. This is typical of a gas composed of polar molecules, where there is a relatively strong interaction with water molecules. **A** and **C** are incorrect. The solubility of a group 18 gas and a non-polar covalent compound would decrease with increasing temperature, but would be at very low values because water molecules would not interact strongly with the gas's single atoms or non-polar molecules. Non-polar covalent compounds would interact using dispersion forces only with water molecules. **B** is incorrect. The solubility of this type of substance usually increases with increasing temperature.

Question 14 B

B is correct. Refer to the reasoning in the solution to **Question 13**.

Question 15 D

D is correct. In this acid, only 0.6% ionisation occurs and so this must be a weak acid. The 0.50 M concentration of the acid indicates that it is dilute.

Question 16 C

The concentration of hydrogen ions in the 0.50 M acid is $\frac{6 \times 0.50}{1000} = 3.0 \times 10^{-3}$ M.

$\text{pH} = -\log_{10}(3.0 \times 10^{-3}) = -(-2.52) = 2.5$

Question 17 C

C is correct. Pipettes and burettes must be given a final rinse with the solutions they are to contain. Water would dilute the solutions and alter their concentrations. The conical flask may be wet as it serves only as the reaction vessel, and is not used for accurate measurement.

Question 18 D

D is correct. Phenolphthalein produces a sharp endpoint when a strong acid reacts with a strong base, or a strong base reacts with a weak acid. Ethanoic acid is a weak acid.

Question 19 D

$n(CH_3COOH) = n(NaOH) = c \times V = 0.945 \times 0.02345 = 0.02216$ mol

$$c\left(CH_3COOH\right) = \frac{n}{V} = \frac{0.02216}{0.0200} = 1.11 \text{ M}$$

Question 20 A

A is correct. Conductivity depends on the presence of ions in the solution. It would be expected that a greater concentration of ions would lead to a higher conductivity. Relevant concentrations of ions are as follows.

A. $0.20 \times 3 = 0.60$ M

B. $0.25 \times 2 = 0.50$ M

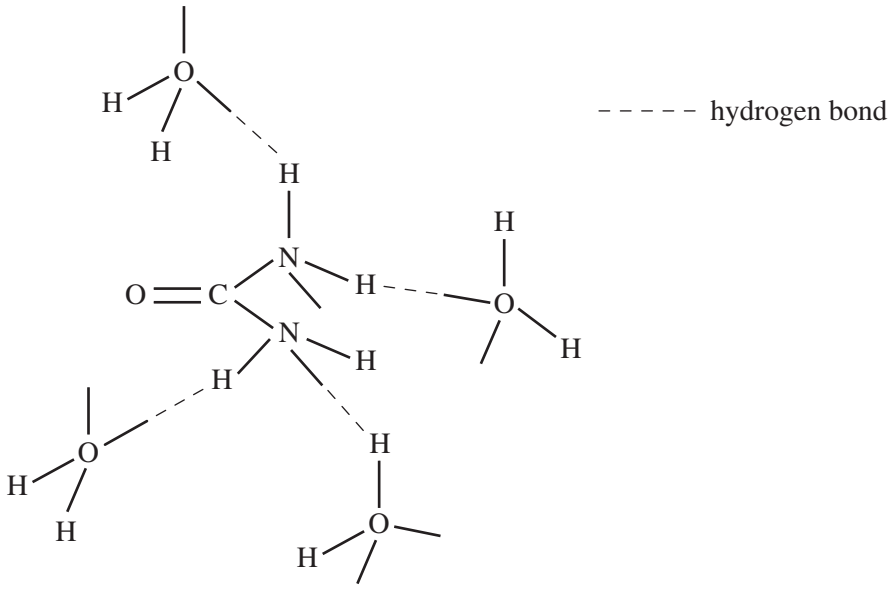
C. $0.30 \times 2 = 0.60$ M, but ionisation of the weak base NH_3 is limited, and so the ion concentration will be less than 0.60 M

D. no ions present as CH_3OH does not ionise in water

SECTION B

Question 1 (9 marks)

a. *For example:*



2 marks
1 mark for correct orientation of water molecules.
1 mark for correct label.

Urea is a small, highly polar molecule, so hydrogen bonding will occur between the H atoms of the water molecules and N atoms of the urea molecule, and between the O atoms of the water molecules and the H atoms of the urea molecule. 1 mark

Note: Dipole–dipole interactions will also occur between the H atoms of the water molecules and the O atom of the urea molecule.

b. **i.** Components will move more slowly through the column when attracted more strongly to the stationary phase. 1 mark

Pesticide D has the longest retention time and so must be the most strongly attracted to the column. 1 mark

ii. The area under the peak is related to the concentration of the component. 1 mark

Even though pesticide C has a higher peak, pesticide D has a greater peak area and so has the highest concentration. 1 mark

iii. The retention time (in seconds) of the pesticides peaks are as follows.

A: 68; B: 79; C: 94; D: 121 1 mark

In the dam water analysis, there are no peaks at the relevant retention times for pesticides A and D. Thus these pesticides were not present in the dam water and so could not have caused the deaths of the fish. 1 mark

Question 2 (11 marks)

a. **i.** HCl is a strong acid that ionises completely in water and so the higher concentration of hydrogen ions causes a more rapid reaction with magnesium. 1 mark

CH_3COOH is a weak acid that ionises only partly in water and so the lower concentration of hydrogen ions produces a slower reaction with magnesium. 1 mark

ii. The mass of magnesium was identical in both experiments and all of the magnesium was used up in each experiment. 1 mark

Thus the total volume of hydrogen gas produced in each experiment must be identical. 1 mark

b. $c_1V_1 = c_2V_2$

$5.75 \times V_1 = 1.0 \times 0.500$

$V_1 = 0.08696$ L 1 mark

To make the diluted acid, take 87.0 mL of 5.75 M HCl and add it slowly to a 500.0 mL volumetric flask containing approximately 200 mL of distilled water. 1 mark

Add distilled water to the flask up to the mark, stopper the flask and agitate the solution to mix well. 1 mark

c. A monoprotic acid has one hydrogen atom per molecule that can ionise and be donated as a proton; that is, the COOH proton. 1 mark

In ethanoic acid, the three hydrogen atoms attached to the carbon atom cannot be ionised and so it is classed as monoprotic. 1 mark

d. $2CH_3COOH(aq) + Mg(s) \rightarrow (CH_3COO)_2Mg(aq) + H_2(g)$ 2 marks

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

Question 3 (10 marks)

a. **i.** $Cr_2O_3(s) + 6HCl(aq) \rightarrow 2CrCl_3(aq) + 3H_2O(l)$ 2 marks

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

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

iii. A more reactive metal will displace a less reactive metal from a solution of its ions. Thus, Al is a more reactive metal than Cr. 1 mark

b. **i.** The chromium forms a protective layer that prevents water and oxygen from being in contact with the iron, so no reaction can occur. 1 mark

ii. Magnesium, zinc and aluminium are more reactive metals than iron. 1 mark

Thus, any corrosion that does occur in the steel will cause any of these reactive metals to displace iron ions and so the iron solid will be reformed, resulting in protection from corrosion. 1 mark

c. **i.** equation II *(as reduction involves a gain of electrons)* 1 mark

ii. $O_2(g)$ 1 mark

iii. $2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4OH^-(aq)$

OR

$2Fe(s) + O_2(g) + 2H_2O(l) \rightarrow 2Fe(OH)_2(s)$ 1 mark

Question 4 (12 marks)

a. i. $Ba^{2+}(aq) + SO_4{}^{2-}(aq) \rightarrow BaSO_4(s)$ 1 mark

ii. The cloudiness indicates that some precipitate of $BaSO_4$ has formed. 1 mark

Thus not all of the $BaCl_2$ solution had reacted in the first precipitation reaction and some $BaCl_2$ solution was present in the filtrate. 1 mark

iii. the type of metal ions present 1 mark

the concentration of metal ions present 1 mark

iv. crystals of $BaCl_2$ and $MgCl_2$ 1 mark

b. i. The solution at a particular temperature has dissolved the maximum mass of solute; that is, no more solute can be dissolved at that temperature (for that volume of solution). 1 mark

ii. At 60°C the solubility is 100 g per 100 g of water, and so in 120 g of solution there is 60 g of solute. 1 mark

iii. 60 g of water 1 mark

iv. At 25°C solubility is 55 g per 100 g of water. As the mass of water is 60 g,

then the amount of dissolved solute is $\frac{55 \times 60}{100} = 33$ g. 1 mark

Therefore the mass of solute that crystallises from the solution is 60 – 33 = 27 g. 1 mark

v. Increasing the temperature will change the saturated solution into an unsaturated solution. 1 mark

Question 5 (7 marks)

a. i. 450 nm *(as this wavelength produces the greatest absorbance)* 1 mark

ii. No other component in the wastewater absorbs strongly at this wavelength. 1 mark

b. i. Prepare a series of food-colouring solutions of known concentration. 1 mark

Measure the absorbance of each solution at the selected wavelength. 1 mark

Plot the graph of absorbance (on the vertical axis) versus concentration (on the horizontal axis). 1 mark

ii. An absorbance of 0.35 indicates a 25 ppm concentration of diluted solution. 1 mark

As the original water was diluted by a factor of 100, then the concentration of the undiluted water sample is 2.5×10^3 ppm. 1 mark

Question 6 (6 marks)

Any three of:

Incorrect statement	Why the statement is incorrect
2	The ionic product of pure water is 10^{-14} M^2 at 25°C but increases with increasing temperature; thus, the $[H_3O^+]$ increases and so the pH changes accordingly.
3	Latent heat of vaporisation is a measure of the energy taken in by a liquid but not evident in a temperature increase when a change of state occurs. Due to the hydrogen bonding between molecules, this is a very high value for water.
4	Heating ice at 0°C does not result in an immediate temperature change as the added heat (latent heat of fusion) is used to change the state from solid to liquid. Molecular kinetic energy is not increased, and so temperature remains constant.
6	Only about 0.5% of the freshwater on Earth is accessible for human use.

6 marks

1 mark for each correctly identified incorrect statement number (up to a maximum of 3 marks).
1 mark for each correct reason showing why the relevant statement is incorrect (up to a maximum of 3 marks).