Neap

Trial Examination 2021

VCE Chemistry Units 1&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**
21	A	B	**C**	D
22	**A**	B	C	D
23	A	B	**C**	D
24	A	B	C	**D**
25	A	B	C	**D**
26	A	B	**C**	D
27	**A**	B	C	D
28	**A**	B	C	D
29	A	B	C	**D**
30	A	**B**	C	D

Question 1 B

B is correct. Only transition metals show variable charges; for example, Cu^{2+} and Cu^{+}. **A**, **C** and **D** are incorrect. A small number of outer-shell electrons, being malleable and conducting electricity are features of all metals.

Question 2 C

C is correct. Metal atoms have few electrons in the outer shell and tend to lose these easily to become ions with a positive charge. The electron configuration of the ion will be identical to that of the previous noble gas. **A** is incorrect. An uncharged atom of an element in the first transition series will have the 3d subshell filled or partly filled but will not have electrons in the 4p subshell. **B** is incorrect. The electron configuration is of a noble gas in the fourth period. **D** is incorrect. Atoms of non-metallic elements usually have almost complete outer shells and so losing electrons is highly unlikely.

Question 3 C

C is correct. The modern periodic table orders elements by atomic number. Vertical groups contain elements with the same outer-shell electron configuration.

Question 4 B

B is correct. The valence shell electron-pair repulsion (VSEPR) model predicts molecular shapes using the principle that bonding and non-bonding electron pairs repel one another as far as possible.

Question 5 B

B is correct. Fullerenes consist of pentagonal and hexagonal arrangements of carbon atoms that fit together like the patches on a soccer ball. **A** and **D** are incorrect. In graphite and graphene, each carbon atom is bonded to three other carbon atoms in a hexagonal arrangement. The structure in the diagram has a hexagonal and pentagonal arrangement. **C** is incorrect. Diamond is a three-dimensional covalent network lattice in which each carbon atom is bonded to four other carbon atoms.

Question 6 A

A is correct and **B** and **C** are incorrect. As there are only three other carbon atoms bonded to each carbon atom, one electron in the outer shell is not confined in a covalent bond. These delocalised electrons can move through the molecule and will conduct electricity. **D** is incorrect. There are no ions in the structure, but the delocalised electrons can also transfer charge.

Question 7 B

B is correct. Shell n: n subshells, n^2 orbitals. Shell 4 has a d subshell. Each d subshell has five orbitals.

Question 8 D

D is correct. Isotopes have the same atomic number, number of electrons, electron configuration and number of outer-shell electrons. **A**, **B** and **C** are incorrect. Isotopes differ in the number of neutrons, nuclear mass and mass number.

Question 9 A

A is correct. CO_2 and HCl: linear

B is incorrect. CH_4: tetrahedral, and SF_6: octahedral

C is incorrect. NH_3: triangular pyramidal, and H_2O: v-shaped

D is incorrect. N_2: linear, and H_2S: v-shaped

Question 10 D

D is correct. The first observation indicates that metal R is the most reactive. The second observation indicates that metal Y is more reactive than metal Q. The third observation indicates that metal X is the least reactive. So the order of increasing reactivity is X < Q < Y < R.

Question 11 C

C is correct. The polymer will soften when heated to moderate temperatures as the dispersion forces between the chains are disrupted progressively with increasing heat. **A** and **B** are incorrect. Thermosetting plastics do not soften when heated to moderate temperatures but will char at high temperatures when covalent bonds within a chain are broken. The structure is a linear polymer with no crosslinking possible between the chains. **D** is incorrect. Both types of plastic may char when heated to high temperatures.

Question 12 A

A is correct. The structure is polyethene and so the monomer is ethene (C_2H_4), with a relative molecular mass of 28.

Question 13 A

A is correct. Crystals of NaCl are formed when ions come out of solution and are deposited in a regular array. The size of the crystals will increase if this happens over a long period of time with many ions available for their formation. In the experiment, a short time for the evaporation process and a low number of ions available will produce crystals of the smallest size.

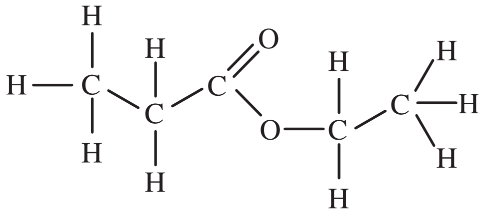
Question 14 D

D is correct. With simple microscopy it is quite easy to identify the size of crystals, which are seen as small, regular-shaped objects. **A**, **B** and **C** are incorrect. An electron microscope can barely reveal individual atoms or ions in some materials. Individual subatomic particles cannot be seen even by an electron microscope, and ions will not be seen by a simple binocular microscope.

Question 15 C

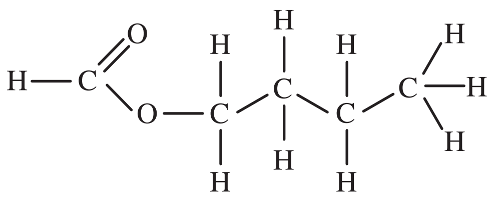
C is correct. Relevant structures and molecular formulas are as follows.

A.



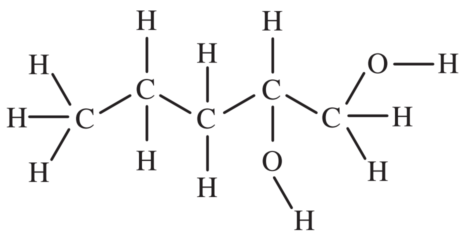
$C_5H_{10}O_2$

B.



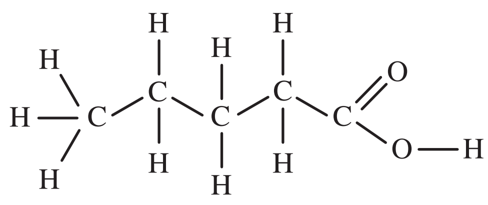
$C_5H_{10}O_2$

C.



$C_5H_{12}O_2$

D.



$C_5H_{10}O_2$

Question 16 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 17 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 18 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 19 B

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

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

Question 20 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 21 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.

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

Question 22 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 23 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 24 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 25 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 26 C

C is correct and **A** and **B** 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 27 A

$$n\left(FeS\right) = n\left(H_2S\right) = n\left(Ag_2S\right) = \frac{m}{M} = \frac{8.581}{247.9} \text{ mol}$$

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

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

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

Question 28 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

Question 29 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.

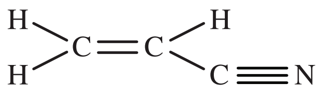
Question 30 B

B is correct. Refer to the reasoning in the solution to **Question 29**.

SECTION B

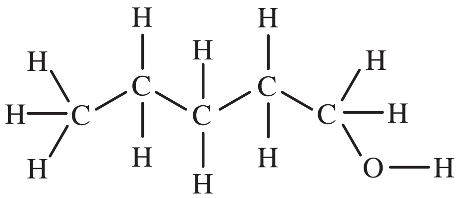
Question 1 (5 marks)

a.



1 mark

b. **i.** *For example:*



1 mark

ii. pentan-1-ol 1 mark

c. The name of the compound is vanadium(II) chloride. 1 mark

The relevant ions are V^{2+} and Cl^{-}, hence the formula is VCl_2. 1 mark

Question 2 (12 marks)

a. A simple mean would produce a value of about 2.0 but the RAM is a weighted mean of the RIM values, taking into account the abundance of each isotope. 1 mark

As the weighted mean produces a RAM value of 1.0, which is close to the RIM of protium, this would indicate that the abundances of both deuterium and tritium are extremely low. 1 mark

b. **i.** *For example:*

The electron configuration of hydrogen is $1s^1$, which is the same as the outer-shell s^1 electron configuration of the elements in group 1. 1 mark

ii. *For example:*

The group 1 elements are reactive metals and hydrogen does not fit into this category. 1 mark

c. **i.** Two hydrogen atoms are joined by a covalent bond so that each atom completes the outer shell by sharing a pair of electrons. 1 mark

A helium atom has a complete outer shell and so there is no requirement to share electrons with another atom. 1 mark

ii. dispersion forces 1 mark

d. **i.** In 1 mole or 18.0 g of water, there are 2.0 g of hydrogen.

$$\% \text{ H by mass} = \frac{2.0}{18.0} \times 100 = 11.1 = 11\% \text{ (to two significant figures)}$$ 1 mark

ii. If 11.1% represents 0.0954 g for hydrogen, then for oxygen:

88.9% represents $\frac{88.9}{11.1} \times 0.0954$ g — 1 mark

mass of oxygen = 0.764 = 0.76 g (to two significant figures) — 1 mark

iii. mass ratio of Al : O = 0.859 g : 0.764 g

mole ratio of Al : O = $\frac{0.859}{27.0} : \frac{0.764}{16.0} = 0.0318 : 0.0478 = 1 : 1.5$ — 1 mark

So the empirical formula of aluminium oxide is Al_2O_3. — 1 mark

Question 3 (12 marks)

a. **i.** H — 1 mark

ii. *Any one of:*

D, E — 1 mark

iii. D — 1 mark

iv. C and E — 1 mark

v. *Any one of:*

A, C, D, E — 1 mark

vi. I — 1 mark

vii. B *(C exhibits dipole–dipole bonding, while A and E both exhibit hydrogen bonding, thus raising their boiling points)* — 1 mark

b. Compound G has a branched structure and so its molecules are unable to pack as close together as the molecules of compound I. — 1 mark

Thus, the intermolecular dispersion forces of compound G are not as intense and so will require less heat to disrupt; that is, compound I will have the higher boiling point. — 1 mark

c. $n(\text{compound E}) = \frac{m}{M} = \frac{0.935}{74.0} = 0.012635$ mol — 1 mark

number of molecules = $n \times N_A = 0.012635 \times 6.02 \times 10^{23} = 0.07606 \times 10^{23}$ — 1 mark

In each molecule there are 11 atoms, therefore:

number of atoms in 0.935 g = $11 \times 0.07606 \times 10^{23} = 0.8363 \times 10^{23} = 8.37 \times 10^{22}$ — 1 mark

Question 4 (10 marks)

a. Magnesium is a reactive metal, whereas gold is not. — 1 mark

Reactive metals lose their valence electrons easily and react readily with other elements to produce more stable compounds, which are deposited as ores. — 1 mark

b. **i.** Solid magnesium chloride consists of magnesium ions and chloride ions held by strong electrostatic attractions in a lattice. The charged particles, ions, cannot move. This movement is necessary for the conduction of electricity. — 1 mark

When molten, the strong bonds are weakened and so the ions are able to move and conduct electricity. — 1 mark

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ii. The ionic bonds holding the ions in the lattice of magnesium chloride are very strong. 1 mark

A large amount of heat is needed to disrupt the bonds. A temperature of 700°C provides sufficient heat for the ionic bonds to be disrupted and for the solid to become molten. 1 mark

iii. hard **OR** brittle 1 mark

c. **i.** aluminium 1 mark

ii. sodium 1 mark

iii. sodium 1 mark

Question 5 (9 marks)

a. As liquid water cools towards the freezing temperature of water, each water molecule forms hydrogen bonds with four other water molecules. 1 mark

This is a very open arrangement, and the molecules are held further apart in an ice crystal than the molecules in liquid water; that is, there is less mass in a given volume. 1 mark

The density of ice is therefore lower than the density of liquid water, and so the ice will float. 1 mark

b. *Any three of:*

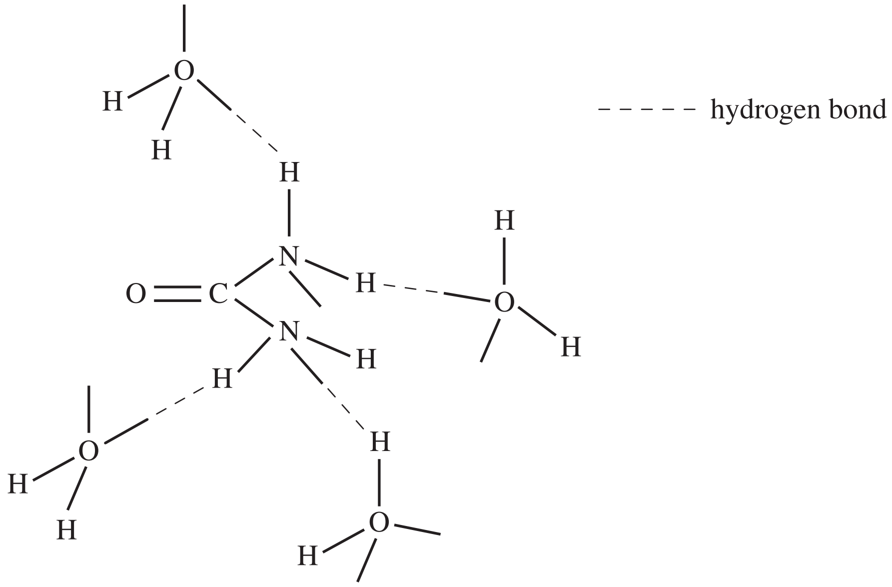
Incorrect statement	Why the statement is incorrect
2	The ionic product of pure water is 10^{-14} M^2 at 25°C but increases with increasing temperature; thus, the $[H_3O^+]$ increases and so the pH changes accordingly.
3	Latent heat of vaporisation is a measure of the energy taken in by a liquid but not 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)

Question 6 (7 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 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 7 (9 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

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

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

Question 8 (9 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

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 9 (10 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

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

Question 10 (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