Neap

Trial Examination 2020

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 D

Alkanes are a family of hydrocarbon compounds with the general formula C_nH_{2n+2}. **A** is incorrect. Only the alkenes have a uniform empirical formula of CH_2, whereas the alkanes and alkynes do not. **B** is also incorrect. Alkenes can be polymerised to produce many polymer materials due to the presence of the double bond C=C in the monomer. Alkanes have only single bonds and are not polymerised. **C** is incorrect. Examining the sequential members of the alkane family CH_4, C_2H_6, C_3H_8, C_4H_{10} and so on reveals that consecutive members differ by $–CH_2$. **D** is correct.

Question 2 A

KCl is an ionic compound but the ions must be free to move in order for a sample to conduct electricity. Thus molten KCl and an aqueous solution of KCl will conduct electricity, whereas solid KCl will not, as the ions are held in fixed positions by ionic bonds.

Question 3 D

Metals conduct electricity because of delocalised electrons and there are none of these in an ionic compound. **A** and **B** are incorrect. All of the samples contain ions as KCl is an ionic compound. Only the samples in which ions could move freely will conduct electricity. **C** is incorrect and **D** is the required answer.

Question 4 C

Crude oil consists of a complex mixture of mainly alkanes, which are composed of hydrogen and carbon. **A** and **B** are incorrect. Crude oil requires separation of the various compounds by fractional distillation before use as a fuel source. **D** is incorrect. **C** is a factual statement about the origins of crude oil and so is the required answer.

Question 5 B

A neutron is ejected from the compound nucleus and so statement I is correct. Bk has 249 nucleons (protons and neutrons) and calcium has 48. The combined total (after allowing for neutron ejection) is greater than 234 (117 × 2) and so statement II is incorrect. Atomic radii of elements increase down the group and so element 117 will have the largest atomic radius of any element in the group. Statement III is incorrect.

Question 6 A

From the Data Booklet, the relative atomic mass of calcium is 40.1. This is the weighted mean of the relative isotopic masses of all of the isotopes of calcium. The relative isotopic mass of ^{48}Ca is approximately 48 and so this would indicate that the lighter isotopes have much higher abundances. The abundance of ^{48}Ca must be exceedingly low to have such little impact on the relative atomic mass of calcium.

Question 7 D

^{48}Ca has 20 protons and 48 – 20 = 28 neutrons. Uncharged atoms would have 20 electrons but the ion has a double-positive charge and so it must have lost two electrons.

Question 8 C

The relevant molecular shapes are as follows:

NF_3 and PH_3 – pyramidal

BF_3 and SO_3 – trigonal planar

C_2H_2 and CS_2 – linear

H_2O and OF_2 – V-shaped

Question 9 B

$M(C_3H_6O_3) = (3 \times 12.0) + (6 \times 1.0) + (3 \times 16.0) = 90.0 \text{ g mol}^{-1}$

$n(C_3H_6O_3) = \frac{m}{M} = \frac{6.59}{90.0} = 0.07322 \text{ mol}$

There are 12 atoms per molecule and so there is $12 \times 0.07322 = 0.879$ mol of atoms.

Question 10 C

Bond polarity is largely determined by the difference in electronegativity of the two elements forming the bond. The greater the difference in electronegativity, the greater the bond polarity. While distance between nuclei and atomic radii of the atoms involved may play a part in bond polarity, they are not the primary factor (**A** and **D** are not the required response).

Question 11 B

As liquid water cools and ice crystals form, the water molecules are arranged in an ordered structure with each molecule forming hydrogen bonds with four other molecules. This is an open structure and so ice is less dense than liquid water. **B** is the required answer. **A** and **C** are incorrect statements. Although **D** is generally correct, the evidence about solid water shows that this is not always the case.

Question 12 A

The intermolecular bonding for the alcohol molecules is hydrogen bonding and dispersion forces. Hydrogen bonding will be similar for each of the four alcohols, given that they each contain one hydroxyl group. However, as the size of the molecules increases, the strength of the dispersion forces also increases, leading to the increased boiling points.

Question 13 C

relative abundance total = 4 + 2 + 5 + 6 = 17

The heaviest isotope has an abundance of 6 and so its % abundance = $\frac{6}{17} \times 100 = 35$.

Question 14 B

$$\text{RAM(Z)} = \left(51 \times \frac{4}{17}\right) + \left(52 \times \frac{2}{17}\right) + \left(54 \times \frac{5}{17}\right) + \left(57 \times \frac{6}{17}\right) = 54.1$$

Question 15 C

The conversions in **A** and **D** could be achieved by dilution. Removal of water will achieve the conversion in **B**. A strong acid cannot be converted into a weak acid as the strength of an acid is a measure of its ability to ionise, and depends on the structure and bonding in the acid. The conversion in **C** is impossible to achieve.

Question 16 B

m(metal chloride) = 43.71 – 32.39 = 11.32 g

m(chlorine) in sample = 11.32 – 8.27 = 3.05 g

ratio of metal to chlorine in the metal chloride = 8.27 : 3.05 = 2.73 : 1.01

Question 17 A

Oxidising agents (oxidants) are electron acceptors. They allow other species to donate electrons and so be oxidised. When an oxidising agent accepts electrons, it is itself reduced.

Question 18 D

Spectator ions are present in reactions in solution, such as in precipitation reactions. They are components of the reactants, but appear unchanged on the products side of the chemical equation. **D** is the required answer. A redox reaction – for example, combustion of a fuel – does not necessarily take place in solution, and so spectator ions may not always be present. **A** is incorrect. Oxidising agents gain electrons in a redox reaction. **B** is incorrect. An acid loses a proton in an acid–base reaction. **C** is incorrect.

Question 19 B

Water is a polar compound with hydrogen bonding between the molecules, whereas cooking oil is essentially non-polar with intermolecular dispersion forces. Water has a high specific capacity, whereas the value for cooking oil would be much lower. Thus it takes more heat to raise the temperature of water by one degree than it does for the oil.

Question 20 A

The mole ratio of HCl : NH_3 is 1 : 1. Both solutions are 0.10 M, so equivalence will be reached after addition of 20.0 mL. The weak base will react completely with the strong acid in the 1 : 1 ratio. The flask initially contains ammonia, so the methyl red indicator will be yellow in the base solution, turning to red at the endpoint.

Question 21 C

$E = mc\Delta T$

For water: $E = 8.0 \times 4.18 \times (60 - 25) = 1170$ J

For lead: $1170 = 40 \times 0.13 \times \Delta T$

$\Delta T = 225°C$

Question 22 C

Reduction is the gain of electrons, so **A** and **D** are incorrect. **B** is not a correct, balanced half-equation as it shows a neutral atom gaining negative charge to become positively charged.

Question 23 B

From the balanced equation and molar masses:

46 g Na reacts with 71 g Cl_2

55 g Na will react with $\frac{55}{46} \times 71 = 85$ g Cl_2 (but only 80 g is available)

Na is in excess as there is insufficient Cl_2 for complete reaction. Some Na will remain after reaction is complete.

Question 24 D

0.246 mol of ethanol = 0.246 × 46 = 11.3 g of ethanol and so **A** and **B** are equivalent.

11.3 g in 1000 mL is equal to 1.13 g in 100 mL; that is, 1.13% m/v, and so **C** is also equivalent.

11.3 g in 1000 mL is equal to 11.3×10^3 g in 10^6 mL; that is, 1.13×10^4 ppm. **D** is not equivalent, and so is the required response.

Question 25 D

The component with the strongest attraction to the mobile phase moves through the column the fastest – that is, P – and so **A** and **B** are incorrect. The area under the peak is a measure of the concentration and so, even though the peak for P is about twice the height of the peak for S, the area of the peak for P is more than twice that of S. **C** is incorrect. The smallest area under any peak is for R and so **D** is the required answer.

Question 26 C

The only peak that is present at the same retention time in both outputs is at 4.0 minutes – that is, component S.

Question 27 A

Solution X: $[H_3O^+] = 10^{-3}$ M and $[OH^-] = 10^{-11}$ M

Solution Y: $[H_3O^+] = 10^{-6}$ M and $[OH^-] = 10^{-8}$ M

A is correct as the hydrogen ion concentration is 1000-times higher for X than Y. **B** and **C** are incorrect. The two solutions could be strong and weak acids, but solution Y could be the same acid as solution X – just more dilute. **D** is incorrect.

Question 28 A

The general rule is that a more-reactive metal will displace a less-reactive metal from a solution of its ions. **A** is the required answer. Metal M is less reactive than metal O and so no displacement will occur in O^{2+} solution. **B** is incorrect. Metal P will react with a solution of N^{2+} ions but the situation in **C** will not occur and so this is incorrect. The situation in **D** does not conform to the general rule as it involves two oxidising agents reacting, and so it is incorrect.

Question 29 B

At 35°C, $[H_3O^+] \times [OH^-] = 2.09 \times 10^{-14}$ M^2.

In pure water, $[H_3O^+] = [OH^-]$ and so $[H_3O^+]^2 = 2.09 \times 10^{-14}$ M^2.

Thus $[H_3O^+] = 1.45 \times 10^{-7}$ M $= 10^{-6.83}$ M and so pH = 6.83.

Question 30 D

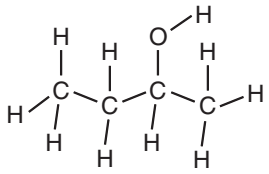
In pure water, $[H_3O^+] = [OH^-]$ irrespective of the temperature and it is always neutral. **D** is correct and **B** is incorrect. The value of the K_w increases with increasing temperature and so $[H_3O^+]$ also increases, but the pH decreases. **A** and **C** are incorrect.

SECTION B

Question 1 (11 marks)

a. Isomers have the same molecular formula ($C_4H_{10}O$) but different arrangement of atoms; that is, different structural formulas, as shown in the table. 1 mark

b.



1 mark

c. 2-methylpropan-2-ol 1 mark

d.

number of covalent bonds in each molecule	
empirical formula	
ability to conduct electricity	
boiling point	✓
percentage by mass of carbon	

1 mark

(*The slight differences in the arrangements of atoms in the molecules will cause slightly different interactions between the molecules, slightly altering both the hydrogen bonding and dispersion forces and so affecting the respective boiling points.)*

e. **i.** Esters are mostly used as flavourings or fragrances in consumer products. 1 mark

ii. propanoic acid 1 mark

(*The ester has seven carbons per molecule and so Q must have three carbons per molecule.)*

f. **i.** In 100 g of the compound:

mass ratio of C : H : O is 37.5 : 12.5 : 50.0 1 mark

mole ratio of C : H : O is $\frac{37.5}{12.0} : \frac{12.5}{1.0} : \frac{50.0}{16.0} = 3.125 : 12.5 : 3.125 = 1 : 4 : 1$

The empirical formula is therefore CH_4O. 1 mark

ii. $n(\text{alcohol}) = \frac{N}{N_A} = \frac{3.67 \times 10^{21}}{6.02 \times 10^{23}} = 0.006096 \text{ mol}$ 1 mark

$M(\text{alcohol}) = \frac{m}{n} = \frac{0.195}{0.006096} = 31.98 = 32 \text{ g mol}^{-1}$ 1 mark

$RMM(CH_4O) = 32.0$

As the masses are equal, the molecular formula is CH_3OH. 1 mark

Question 2 (7 marks)

a. **i.** *Any one of the following:*

- malleability
- electrical conductivity
- thermal conductivity

1 mark

ii. Metals consist of an array of cations with delocalised electrons moving freely throughout the lattice, and holding the array together by the electrostatic attraction to the cations. 1 mark

Any one of the following:

- **Malleability:** When the metal is hammered, the metal cations can move over each other but still remain intact due to the attraction of the delocalised electrons.
- **Electrical conductivity:** Delocalised electrons are free to move and carry the current when a potential difference is applied.
- **Thermal conductivity:** Delocalised electrons are free to move to transfer thermal energy through the metal.

1 mark

b. Compared to main-group metals, transition metals generally have higher *(any one of the following)*:

- melting points
- boiling points
- densities

1 mark

c. K, Mg, Fe, Pb 1 mark

d. *Any one of the following rows:*

Modification	Purpose of this modification (fill only one row)
coating iron with zinc to make galvanised iron sheets	• **Iron will rust if left exposed to the air and water.** • **Coating with zinc forms a physical barrier to prevent corrosion (*and zinc may act as a sacrificial anode if the iron becomes exposed*).**
annealing by heating iron to red-hot and then cooling slowly	• **Untreated iron is unsuitable for many applications because it is soft and brittle.** • **Heat treatment (annealing) changes the properties of iron so that it becomes harder and more flexible.**
mixing molten iron with carbon and other molten metals to make stainless steel	• **Untreated iron is unsuitable for many applications because it is soft, brittle and easily corroded.** • **Alloying iron produces a metallic material that has properties that suit the application – for example, corrosion resistance.**

2 marks

Note: Students must give both bullet points in the respective row for full marks.

Question 3 (8 marks)

a. Electrons can move only in certain fixed energy levels around the nucleus. 1 mark

Electrons can jump from one energy level to a higher level if sufficient energy is supplied. 1 mark

When electrons return to a lower energy level, a discrete amount of energy is emitted, equivalent to the difference between the energy levels; this is seen as light of a particular wavelength. 1 mark

b. **i.**

number of subshells	**3**
total number of orbitals	**9**
maximum number of electrons	**18**
number of p-type orbitals	**3**

4 marks
1 mark for each correct entry in table.

ii. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^2$ 1 mark

Question 4 (13 marks)

a. **i.** decreases 1 mark

ii. decreases 1 mark

b. Elements in the same group in the periodic table have similar chemical properties. The properties of element 114 should be similar to the other elements in the group. 1 mark

Elements in the same group in the periodic table show trends in their physical properties. The properties of element 114 can be predicted based on the trends seen in other elements in the group. 1 mark

c. To conduct electricity these covalent substances would need to have delocalised electrons – that is, electrons that are not involved in a covalent bond and are free to move through the structure. 1 mark

In diamond, each carbon atom is bonded to four other carbon atoms and so there are no delocalised electrons, resulting in no conduction of electricity. 1 mark

In each of the other forms of carbon, each carbon atom has fewer than four covalent bonds, resulting in delocalised electrons that will conduct electricity. 1 mark

d. **i.** Discrete molecules have weak intermolecular attractive forces and so require a small amount of energy to cause melting – that is, a low melting temperature. 1 mark

The very high melting temperature would indicate that this covalent substance (SiO_2) does not consist of discrete molecules. 1 mark

ii. O=C=O

1 mark

Any small negative charge ($\delta-$) that forms on the oxygen atoms is spread on both ends of the molecule and so no overall dipole with distinct positive and negative ends will result – that is, the molecule is non-polar. 1 mark

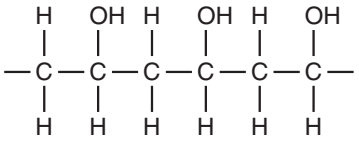
iii. covalent bonds 1 mark

dispersion forces 1 mark

(There are covalent bonds between the atoms of the CO_2. As CO_2 is a non-polar molecule, there are dispersion forces only between the molecules.)

Question 5 (4 marks)

a.



1 mark

b. PVA is a long-chain carbon polymer with covalent bonds within the chain and with weak intermolecular forces of attraction between the polymer chains. 1 mark

A thermosetting polymer is a long-chain carbon polymer with covalent bonds within the chains and with various degrees of cross-linking (covalent bonds) between the chains. 1 mark

The thermosetting polymer will be more rigid and will not soften when heated, whereas the thermoplastic is softer and more flexible and will soften when heated. 1 mark

Question 6 (11 marks)

a. **i.** $HSO_4^-(aq) + H_2O(l) \rightleftharpoons SO_4^{2-}(aq) + H_3O^+(aq)$ 1 mark

(second ionisation is not complete; $\rightleftharpoons$ is used to show this)

ii. It is an acid that readily donates a proton to water.

OR

It is an acid that is completely ionised in water *(for the first proton only)*. 1 mark

b. $c_1V_1 = c_2V_2$

$18 \times V_1 = 1.5 \times 125$ 1 mark

$V_1 = 10.4 = 10$ L 1 mark

c. As HCl is a strong acid, all of the molecules ionise in the reaction with water and so:

$[H^+] = 1.0$ M $= 10^0$ M; that is, pH = 0. 1 mark

As sulfuric acid is also a strong acid but can donate two protons:

$[H^+] > 1.0$ M and so $[H^+] > 10^0$ M; that is, pH < 0. 1 mark

d. **i.**

Solution A	Gas B	Solid D
zinc sulfate	hydrogen	sodium carbonate **OR** sodium hydrogen carbonate

3 marks

1 mark for each correct answer.

ii. $H_2SO_4(aq) + CuO(s) \rightarrow CuSO_4(aq) + H_2O(l)$

OR

$H_2SO_4(aq) + Cu(OH)_2(s) \rightarrow CuSO_4(aq) + 2H_2O(l)$

2 marks

1 mark for correct reactants and products.
1 mark for correct balancing and states.

Question 7 (7 marks)

a. $n = cV = 0.100 \times 0.050 = 5.0 \times 10^{-3}$ mol 1 mark

$m(K_2SO_4) = n \times M = 5.0 \times 10^{-3} \times 174.3 = 0.87$ g 1 mark

b. $Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$ 1 mark

c. Some of the precipitate would stick to the sides of the beaker and so, by washing this solid off, all of the precipitate will be present on the filter paper. 1 mark

d. nitrate ions and potassium ions 1 mark

e. **i.** percentage yield = $\frac{1.38}{1.52} \times 100 = 90.8$ % 1 mark

ii. *Any one of:*

- Some precipitate was lost during filtration.
- Not all of the ions precipitated in step 2.

1 mark

Question 8 (9 marks)

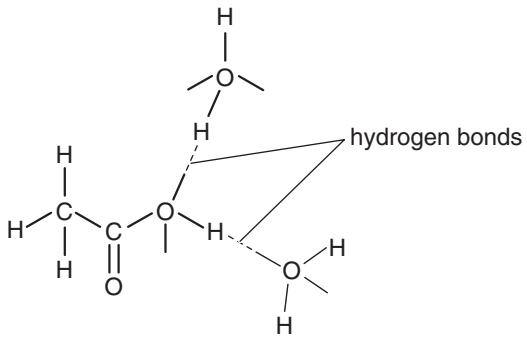
a. **i.** The solubility decreases with increasing temperature, whereas for most solids solubility would increase with increasing temperature. 1 mark

ii. The solubility at 30°C is 52 g per 100 g of water – that is, 26 g per 50 g of water. 1 mark

Place 26 g of sodium sulfate in 50 mL of pure water at 30°C and stir until no more solid will dissolve. 1 mark

iii. Add more solid and try to dissolve it at 30°C; if it is a saturated solution, no more solid will dissolve. 1 mark

b. **i.**



2 marks

1 mark for correct drawing of the molecular interactions.
1 mark for correct orientation of water molecules and labels.

Compound A is a small molecule that is capable of forming hydrogen bonds with water molecules and so it will be kept in solution. 1 mark

ii. Even though compound B has the same polar functional group as compound A, most of the large molecule is non-polar. 1 mark

Water molecules will not form significant intermolecular bonds with the large non-polar tail of the compound and so its solubility is very low. 1 mark

Question 9 (7 marks)

a. i. The concentration of cadmium in the samples was too high for the calibration graph to be used. 1 mark

(*Dilution of the samples so that their absorbance relates to a cadmium concentration on the graph is the correct procedure, rather than extrapolation of the graph.*)

ii. absorbance of 0.45 → 5 ppm 1 mark

Accept responses between 4.5 and 5.5 ppm.

The concentration of the undiluted sample = 5 × 5 = 25 ppm. 1 mark

iii. 25 ppm = 25 mg per litre and so in 5000 litres there is 5000 × 25 mg = 125 000 mg. 1 mark

mass of cadmium = 0.13 kg 1 mark

b. i. *For example*:

AAS devices are expensive, but gravimetric analysis can be undertaken in any laboratory using basic apparatus and equipment. 1 mark

ii. *For example, any one of*:

- Analysis by AAS produces results much faster than the labour-intensive gravimetric analysis method.
- AAS is inherently more accurate than gravimetric analysis as there is no possibility of most of the errors that can occur in gravimetric analysis (*for example, interference by other metals in the sample*).

1 mark

Question 10 (8 marks)

a. i. $n(\text{NaOH}) = cV = 0.127 \times 0.02235 = 0.002838 \text{ mol} = 2.84 \times 10^{-3} \text{ mol}$ 1 mark

ii. $n(\text{OH}^-) = n(\text{H}^+) = 0.002838 \text{ mol} = 2.84 \times 10^{-3} \text{ mol}$ 1 mark

iii. $c(\text{H}^+ \text{ ions}) = \frac{n}{V} = \frac{0.002838}{0.02000} = 0.142 \text{ M}$ 1 mark

iv. $\text{pH} = -\log_{10}[\text{H}^+] = -\log_{10}(0.142) = 0.85$ 1 mark

b. Animals and plants function properly within a narrow pH range. 1 mark

An environment outside this narrow range will impair proper functioning of living organisms, leading to disease and possibly death. 1 mark

c. NaOH absorbs water from the air, and NaOH reacts with carbon dioxide from the air. 1 mark

A pure sample of the solid cannot be obtained, and so a known accurate mass of NaOH cannot be determined. 1 mark

Question 11 (5 marks)

a. **i.** acid *(H_2O donates a proton and becomes OH^-)* 1 mark

ii. The HCl produced increases the hydrogen ion concentration and so lowers the pH. 1 mark

b. **i.** $H_2S(g) \rightarrow S(s) + 2H^+(aq) + 2e^-$ 1 mark

ii. $MnO_2(s) + 4H^+(aq) + 2e^- \rightarrow Mn^{2+}(aq) + 2H_2O(l)$ 1 mark

iii. *For example:* Fe^{2+} or H_2O 1 mark

