Neap

Trial Examination 2020

VCE Chemistry Unit 1

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

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 C

Both factors affect the formation of crystals. Slowing the rate of cooling (factor I) will increase the size of the crystals. Crystal formation will not occur in dilute solutions and so the concentration of the solution (factor II) is a critical determinant of crystal formation.

Question 12 A

Zinc oxide is an ionic compound, and ionic compounds typically are hard and brittle with a high melting point due to the strong ionic bonds holding the ions together in the crystals.

Question 13 D

Even though **A** is a factual statement, there is no evidence that its transparency should provide greater protection from UV radiation. **A** is not a probable reason for increased effectiveness. **B** is factually incorrect as nanoparticles have an enormous surface area-to-volume ratio. While properties of nanoparticles can be different from those of the same material in bulk form, it is not the case for all properties, so **C** is not the best response to explain the change in sunscreen effectiveness. **D** provides a sensible explanation as to why the nanoparticle sunscreen is more effective.

Question 14 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 15 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 16 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 17 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 18 D

Crystalline areas in a polymer occur when the polymer chains pack closely together so that the interactive forces are intense. This produces a polymer that has high strength, rigidity, high density and a low transmission of light. High transparency is not a property of this type of polymer and so **D** is the required answer.

Question 19 A

Features that prevent a high percentage of crystalline areas do not allow close packing of the polymer chains. The conditions shown in **B**, **C** and **D** would prevent close packing of the polymer chains and so the interactive forces between the chains would be less intense. There would be a low percentage of crystalline areas in these polymers.

Question 20 B

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

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

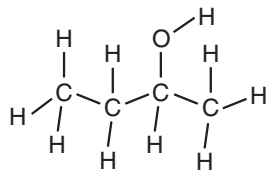
ratio of metal to chlorine in the metal chloride = 8.27 : 3.05 = 2.73 : 1.01

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 (10 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. *For example*:

Lead has high density. 1 mark

It is used as 'sinkers' in fishing lines so that the line and hook will be held under water and not float. 1 mark

e.

Extraction method	roasting and then reacting with C or CO or H_2	using a blast furnace	using electrolysis
Metals extracted with this method	**Pb**	**Fe**	**K and Mg**

1 mark

*(**Roasting and then reacting:** By heating strongly, the oxygen in the air reacts with the non-metal component of the ore to convert the ore to an oxide. The reactant in the second reaction removes the oxygen from the roasted ore, leaving the metal, which can be further refined.*

***Using a blast furnace:** Ore is heated to very high temperatures and a series of chemical reactions occur between the ore and the materials in the furnace. The molten metal is tapped off at the bottom of the furnace and the other products formed are waste gases and slag, which are removed separately.*

***Using electrolysis:** The ore is melted and used as the electrolyte in a cell that contains two electrodes. Electricity is used so that one electrode is made negative and the molten metal positive ions are attracted to it and gain electrons to form metal atoms.)*

f. *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

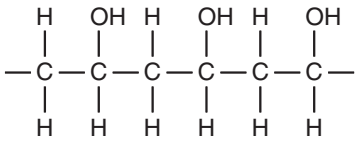
iii. covalent bonds 1 mark

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 (8 marks)

a. **i.**



1 mark

ii. 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

b. **i.** Hydrogen bonding occurs when PVA glue takes effect. 1 mark

The partial charges on the atoms of the OH groups in the glue and on the surfaces will attract electrostatically to produce strong intermolecular bonding (hydrogen bonding). 1 mark

ii. There are no overall charges on metals and so there will be no significant attraction between the PVA molecule and the surface of a metal. 1 mark

iii. Water from rain could disrupt the hydrogen bonding between the PVA glue and a bonded surface, causing the glue to fail. 1 mark