Neap

Trial Examination 2022

VCE Chemistry Units 3&4

Written Examination

Suggested Solutions

SECTION A – MULTIPLE-CHOICE QUESTIONS

Question	Answer	Question	Answer	Question	Answer
1	D	11	C	21	B
2	D	12	A	22	A
3	B	13	B	23	D
4	B	14	A	24	A
5	D	15	B	25	C
6	C	16	A	26	B
7	C	17	C	27	A
8	B	18	D	28	C
9	D	19	D	29	C
10	A	20	C	30	A

Question 1 D

D is correct. Activation energy (E_a) is the energy required to initiate a reaction. A catalyst lowers the E_a by using a different pathway for the reaction.

A and **B** are incorrect. Enthalpy change is defined as the heat (enthalpy) of the products minus the heat (enthalpy) of the reactants. A catalyst has no effect on these quantities.

C is incorrect. Only temperature affects the value of the equilibrium constant.

Question 2 D

D is correct. Starch is a polymer of glucose units, and the glycosidic linkages are formed by the removal of one water molecule per link, that is, a condensation reaction.

A is incorrect. Water is a product, not a reactant, in a condensation reaction.

B is incorrect. The breaking down of sucrose is a hydrolysis reaction.

C is incorrect. Amino acids being produced from a tripeptide is a hydrolysis reaction.

Question 3 B

B is correct. Some enzymes can function alone to produce an increased reaction rate; however, some enzymes require a coenzyme and so do not function alone. Coenzymes do not function alone to catalyse reactions.

A is incorrect. This description applies to both enzymes and coenzymes.

C is incorrect. This description applies to coenzymes but not to enzymes. Coenzymes are often derived from vitamins and are organic molecules that bind to the active sites of enzymes during catalysis.

D is incorrect. Enzymes always contain an active site, but those enzymes that require a coenzyme to function have their active site modified by the addition of the coenzyme fitting in to it. Further, in the induced fit model of enzyme action, the active site may alter its shape.

Question 4 B

The first equation has been halved and reversed to produce the second equation. Thus, the equilibrium constant, K_c, of the second reaction is $\left(\frac{1}{K_c}\right)^{\frac{1}{2}} = \left(\frac{1}{97.5}\right)^{\frac{1}{2}} = 0.101$.

Question 5 D

D is correct. A 2-amino acid has the COOH and NH_2 groups attached to C_2. This molecule does not have this arrangement and so is not a 2-amino acid. A zwitterion is a dipolar ion and has a proton removed from the COOH group and a proton added to the NH_2 group.

A is incorrect. In a high pH environment, the amino group would be uncharged as it would not gain a proton.

B is incorrect. In a low pH environment, the carboxyl group would be uncharged as it would not lose a proton.

C is incorrect. The molecule is not a 2-amino acid as both the COOH and NH_2 groups are not attached to C_2.

Question 6 C

The ester present in the highest concentration has the largest area under its peak. Ester 3 has the largest peak area, even though ester 1 has a taller peak. The ester with the weakest attraction to the stationary phase is the ester that moves through the column the fastest, meaning it has the lowest retention time. Ester 1, therefore, has the weakest attraction to the stationary phase.

Question 7 C

A peak area of 8500 units corresponds to a concentration of 8.5×10^{-2} M. The original solution was diluted 1 in 10, so the concentration of the undiluted solution is $10 \times 8.5 \times 10^{-2} = 0.85$ M.

Question 8 B

energy in 900 g of octane = 47.9 × 900 = 43 110 kJ

energy in 100 g of ethanol = 29.6 × 100 = 2960 kJ

total energy in 1.00 kg of E10 = 43 110 + 2960 = 46 070 = 4.61×10^4 kJ

Question 9 D

D is correct. The body needs large amounts of amino acids in proteins to form structural and biochemical molecules. Vitamins are required in much smaller amounts.

A and **B** are incorrect. Vitamin C is a water-soluble vitamin and cannot be synthesised in the human body.

C is incorrect. Vitamins C and D are markedly different in their structures and so have different physical properties such as solubilities in different solvents and different melting points.

Question 10 A

A is correct. Arachidonic acid has a greater number of C=C bonds (four) than the other fatty acids and so would require the largest amount of antioxidant to protect it from oxidative rancidity.

B is incorrect. Linolenic acid has three C=C bonds.

C is incorrect. Palmitoleic acid has one C=C bond.

D is incorrect. Arachidic acid has no C=C bonds.

Question 11 C

$$\begin{aligned}\%\text{ atom economy} &= \frac{M(\text{desired product})}{M(\text{reactants})} \times 100 \\ &= \frac{130}{148} \times 100 \\ &= 87.8\%\end{aligned}$$

Question 12 A

A is correct. Fluorine ions, F^-, travel to the positive electrode (the anode) in the electrolytic cell. At this electrode, the oxidation shown in the half-equation $2F^-(l) \rightarrow F_2(g) + 2e^-$ occurs.

B, **C** and **D** are incorrect. These options do not identify the correct electrode name and polarity.

Question 13 B

B is correct. Hydrogen ions, H^+, undergo reduction at the cathode to produce hydrogen gas, H_2. H_2 gas is a reductant and so will not react with other reductants such as copper, iron or inert carbon. Iron or carbon (graphite) would most likely be the least expensive option for a manufacturer. The F^- ion is a weak reductant and will not be oxidised if stronger reductants such as copper and iron are present. Fluorine gas, F_2, is a very strong oxidant and so if it were to form, it would react readily with copper or iron. The anode must therefore be made from an inert material such as carbon.

A, **C** and **D** are incorrect. These options do not identify likely compositions of the electrodes.

Question 14 A

A is not a correct statement and is therefore the required response. A high proportion of amylopectin to amylose results in a high glycaemic index (GI) value.

B, **C** and **D** are incorrect. These options are correct statements about GI and are therefore not the required response.

Question 15 B

B is correct. The 500 km journey used 74.5 L of petrol and (19.5 × 5 =) 97.5 L of liquefied petroleum gas (LPG). Petrol therefore has a higher energy content per litre than LPG.

A is incorrect. Petrol and LPG are both derived from crude oil, which is a fossil fuel.

C is incorrect. Unless the engines were perfectly tuned so that the fuel and oxygen gas were in exact stoichiometric ratios for complete combustion, some carbon monoxide gas, CO, would have been produced during both journeys.

D is incorrect. LPG is a gas at room temperature but is kept as a liquid via external pressure. A tank storing LPG cannot be filled using atmospheric pressure as the fuel will vaporise.

Question 16 A

total LPG used = 97.5 L

CO_2 emissions = 1.63×10^5 g

$$CO_2 \text{ emissions in grams per litre of LPG burnt} = \frac{1.63 \times 10^5}{97.5} = 1672 = 1.67 \times 10^3 \text{ g L}^{-1}$$

Question 17 C

C is correct. Cell voltage is calculated for each half-cell pair using the rule E^0 cell = E^0 oxidant – E^0 reductant. For half-cells 1 and 3, 0.80 – (–1.66) = 2.46 V.

A is incorrect. For half-cells 1 and 2, 0.80 – (–0.25) = 1.05 V.

B is incorrect. For half-cells 3 and 4, 0.34 – (–1.66) = 2.00 V.

D is incorrect. For half-cells 2 and 4, 0.34 – (–0.25) = 0.59 V.

Question 18 D

D is correct. The bracketed numbers are the relative peak areas, which show the ratio of the numbers of protons causing each peak. The chemical shift numbers (ppm) can be used with the ^{1}H NMR data table in the Data Booklet to identify the type of proton causing each peak. For example, $\delta = 1.15$ ppm indicates a CH_3 proton.

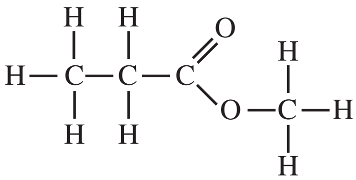
A is incorrect. Functional groups are usually determined using infrared spectroscopy (IR), not NMR. In addition, the peak area numbers do not identify proton environments or functional groups.

B is incorrect. The chemical shift numbers are too small for a ^{13}C NMR.

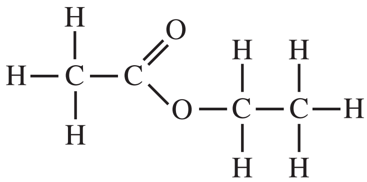
C is incorrect. The significance of the information is reversed in this option.

Question 19 D

D is correct. The chemical shifts and splitting pattern (ratio 2 : 3 at 2.32 and 1.15 with a splitting pattern quartet/triplet) suggest a CH_3CH_2 combination. Combined with the ester functional group, there are two possible structures, which are shown below.



methyl propanoate



ethyl ethanoate

Therefore, methyl propanoate is the correct option.

A is incorrect. Butanoic acid is not an ester.

B and **C** are incorrect. These compounds would not produce the pattern shown on the NMR spectrum. Methyl methanoate has only two ^{1}H types, and so has two peaks on its spectrum only. 1-propyl methanoate has four ^{1}H types, which produces four peaks.

Question 20 C

$$\text{total energy from cereal} = \text{energy (protein)} + \text{energy (fat)} + \text{energy (carbohydrate)}$$

$$1627 = (11.6 \times 17) + (17.8 \times 37) + (m(\text{carbohydrate}) \times 16)$$

$$m(\text{carbohydrate}) = 48.2 \text{ g}$$

Question 21 B

B is correct. A biofuel is a fuel derived from organic material that was recently living. Decomposing organic waste produces methane gas.

A, **C** and **D** are incorrect. Fossil fuels, such as coal seam gas and coal, are derived from organic materials but the organic materials from which they are derived were not recently living.

Question 22 A

A is correct. In the fuel cell, reduction of the oxidant, O_2, occurs at the cathode. This cell uses an alkaline electrolyte.

B is incorrect. This half-equation represents an oxidation reaction, which does not occur at a cathode.

C is incorrect. This reaction involves the H^+ ion, which will not persist in an alkaline environment.

D is incorrect. This half-equation does not represent the reaction at the cathode and is not correctly balanced.

Question 23 D

D is correct. A pressing issue associated with the use of hydrogen gas in cars is the problem of safely storing sufficient amounts of the gas that match the energy content of common fuels, for example, petrol. As hydrogen is a gas at room temperature, it must be compressed and/or cooled so that a sufficient amount can be stored for a car to have a reasonable travel range before refuelling is required. Hydrogen is also explosive when mixed with air, so leaks are a major concern.

A is incorrect. The E_a is lowered by use of catalytic electrodes, not temperature.

B is incorrect. Oxygen gas is not flammable.

C is incorrect. Fuel cells are highly efficient as they involve only one energy transformation (chemical to electrical) and so there is minimal energy loss.

Question 24 A

Using $\frac{p_1V_1}{n_1T_1} = \frac{p_2V_2}{n_2T_2}$, where $p_1 = p_2$, $n_2 = 2n_1$ and $V_1 = V_2$ gives:

$$\frac{1}{293} = \frac{1}{2T_2}$$

So, $T_2 = 146.5$ K $= 146.5 - 273 = -126.5 = -127$°C.

Question 25 C

C is correct. In the aspartame molecule, there is a peptide bond (CONH) and an ester linkage (COO).

A, **B** and **D** are incorrect. There is no glycosidic linkage in the aspartame molecule.

Question 26 B

When recharging a lithium-ion battery, the power recharger pumps electrons from where they were used in the battery (at the positively charged cathode) back to where they were produced in the battery (at the negatively charged anode). Thus, the positive terminal of the power recharger pulls electrons from the positive electrode of the battery and causes the spontaneous reduction reaction in the battery to reverse. Similarly, the negative terminal of the power recharger forces electrons onto the negative electrode of the battery, causing the spontaneous oxidation reaction to reverse.

Question 27 A

A is correct. Only reasons I and II are plausible. Reason I is a brief summary of collision theory. Reason II explains why some cells are not rechargeable – the products of the spontaneous reaction diffuse away from the electrodes and so cannot be used as reactants for recharging.

B, **C** and **D** are incorrect. Reason III is not plausible. Metals conduct electricity at reasonably high and low temperatures.

Question 28 C

C is correct. The E_a of the forward reaction is 250 kJ mol^{-1}. The E_a of the reverse reaction is 44 kJ mol^{-1}.

A and **B** are incorrect. The forward reaction is endothermic with enthalpy change (ΔH) = 250 – 44 = +206 kJ mol^{-1}.

D is incorrect. The reverse reaction is exothermic with $\Delta H = 44 - 250 = -206$ kJ mol^{-1}.

Question 29 C

energy required to heat the water = $mc\Delta T = 250 \times 4.18 \times 21.0 = 21\,945$ J

A greater amount of heat must have been released by the fuel as only 75% was used in the heating.

Thus, the amount released $= \dfrac{21\,945}{0.75} = 29\,260$ J.

energy per gram $= \dfrac{29\,260}{1.15} = 25\,443 \text{ J g}^{-1} = 25.4 \text{ kJ g}^{-1}$

Question 30 A

A is correct. The area under the curve is a measure of the total number of particles. As the area did not change, this means that the total number of particles did not change. This statement is therefore inconsistent with the change made to the gas sample based on the information provided.

B, **C** and **D** are incorrect. These statements are consistent with the change made to the gas sample. The graph flattening and the peak moving to the right indicate that the change was a temperature increase. With a temperature increase, particles collide more frequently and the average kinetic energy of the particles increases.

SECTION B

Question 1 (11 marks)

a. **i.** The reactant is derived from crude oil, which is a finite resource formed over millions of years. 1 mark

Once all known reserves of crude oil are used up, this chemical method will not be able to be used and so producing ethene in this way is not sustainable. 1 mark

ii. Yeast enzymes convert plant sugars to ethanol (C_2H_5OH) via the process of fermentation in the absence of oxygen. 1 mark

The mixture produced by fermentation is distilled. Based on the different boiling temperatures of the mixture's components, bioethanol is isolated. 1 mark

b. **i.** $C_2H_4 + HCl \rightarrow C_2H_5Cl$ 1 mark

ii. *Any one of:*

- substitution
- halogenation
- chlorination

1 mark

iii. oxidation 1 mark

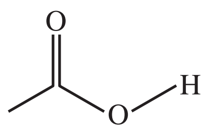
iv.

	Chemical name	Reaction conditions
Reactant B	chlorine	*Any one of:* • ultraviolet light • heat
Reactant D	*Any one of:* • hydroxide ion • sodium hydroxide • potassium hydroxide	

3 marks

1 mark for each correct cell.

v.



1 mark

Question 2 (8 marks)

a. **i.** energy storage 1 mark

ii. Cellulose can be broken down by a particular enzyme to produce monosaccharides. Humans do not have this enzyme in the body, so cellulose cannot be digested *(although some microbes in the gut can digest some cellulose)*. 1 mark

ChemU34_SS_2022

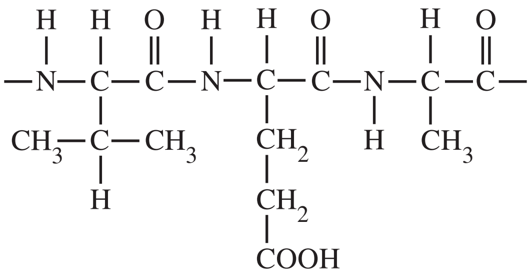
b. **Tertiary structure:** Tertiary structure is the overall three-dimensional shape of a protein molecule, which is held together by interactions between the atoms in the side groups of the amino acid residues of the protein chain. 1 mark

In the insulin molecule, the disulfide bond in the upper chain is a type of interaction involved in the tertiary structure. *(Other interactions are hydrogen bonding, ionic bonding and dispersion forces.)* 1 mark

Quaternary structure: Quaternary structure is the interaction between different polypeptide chains in a protein molecule, which gives the molecule its overall structure. 1 mark

In the insulin molecule, the two disulfide bonds between the two polypeptide chains hold the protein in a particular molecular arrangement. 1 mark

c.



2 marks

1 mark for showing the correct side chain on the middle amino acid.
1 mark for showing two correct peptide links between the amino acids.

Question 3 (7 marks)

a. n(sodium hydroxide (NaOH)) = cV = 0.110 × 0.250 = 0.0275 mol 1 mark

m(NaOH) = $n \times M$ = 0.0275 × 40.0 = 1.10 g 1 mark

1.10 g of NaOH pellets was weighed and then transferred to a 250 mL volumetric flask. The flask was then half-filled with distilled water. The flask was swirled to dissolve the pellets and filled to the calibration line with distilled water. The flask was inverted several times to mix the solution. 1 mark

b. NaOH pellets absorb moisture from the air and react with carbon dioxide (CO_2) in the air. 1 mark

A primary standard requires that a mass of a pure compound contains a known number of moles. However, NaOH will be 'wet' and will not be a pure compound, so an accurate amount cannot be obtained. 1 mark

c. For accuracy, the titre volume used in calculations must be derived from quantities that are within approximately 0.05 mL of each other (concordant titres). 1 mark

The volumes used to obtain the average of 17.70 mL vary by as much as 0.25 mL; thus any calculations made using this average volume would not be accurate. 1 mark

Question 4 (10 marks)

a. **i.** The molecule in biodiesel consists of two covalently bonded hydrocarbon chains joined together by an ester linkage (COO), that is, $CH_3OOC(CH_2)_{16}CH_3$. 1 mark

The hydrocarbon chains are non-polar, while the ester linkage is a polar group of atoms. 1 mark

ii. The molecule consists of carbon atoms covalently bonded in a chain with hydrogen atoms covalently bonded to carbon atoms, that is, $CH_3(CH_2)_{10}CH_3$. 1 mark

The hydrocarbon molecule is non-polar. 1 mark

b. **i.** Viscosity depends on the movement of molecules. Molecular movement in both fuels is influenced by the strength of the intermolecular bonding between the molecular chains. 1 mark

Increasing temperatures disrupt the intermolecular bonding and allow greater movement of the chains, thus lowering viscosity. 1 mark

ii. The higher viscosity of biodiesel in cold conditions makes it an unsuitable fuel selection as it will move more slowly in fuel lines. 1 mark

As petrodiesel has a much lower viscosity than biodiesel in cold conditions, it is the better choice of fuel as it will move more quickly in fuel lines. 1 mark

c. 1 MJ of energy released produces 7.4 g of CO_2, so 10^6 g of the gas forms when $\frac{10^6}{7.4}$ MJ of energy is released. 1 mark

For this petrodiesel, there is 0.043 MJ for 1.0 g of fuel combusted.

mass of petrodiesel that would need to be burnt $= \frac{\frac{10^6}{7.4}}{0.043} = 3.1 \times 10^6$ g 1 mark

Question 5 (9 marks)

a. $K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$, so $[NH_3]^2 = K_c \times [N_2][H_2]^3$ 1 mark

$[N_2] = \frac{n}{V} = \frac{0.46}{2.0} = 0.23$

$[H_2] = \frac{n}{V} = \frac{0.96}{2.0} = 0.48$

$[NH_3]^2 = 640 \times 0.23 \times 0.48^3 = 16.28$, so $[NH_3] = 4.03$ M 1 mark

$n(NH_3) = cV = 4.03 \times 2.0 = 8.1$ mol 1 mark

b. **i.** Although higher pressures at a particular temperature produce a higher yield of ammonia at a faster rate, it is costly to build high-pressure vessels for the reaction and maintain high pressures in the vessels. 1 mark

It is more economical for a manufacturer to use a lower pressure of 250 atm and achieve a reasonable yield at an acceptable rate of reaction. 1 mark

ii. A conflict arises because higher temperatures produce a faster rate of reaction, but a lower yield. Similarly, lower temperatures favour yield at the expense of a slower reaction rate. 1 mark

At a moderate temperature of 400°C, a manufacturer achieves a reasonable yield at an acceptable rate of reaction. 1 mark

iii. The catalyst increases the rate of reaction, so a lower temperature can be used, which is beneficial for the reaction yield. 1 mark

The sponge-like form of the catalyst has a greater surface area on which more reactants can bond and interact and so produces a faster rate of reaction. 1 mark

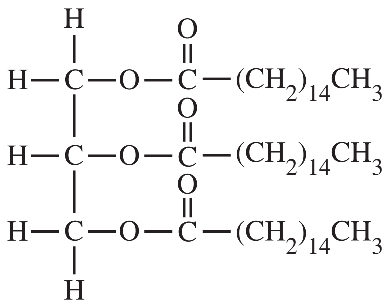
Question 6 (5 marks)

a. Palmitic acid has the highest melting point. 1 mark

These non-polar fatty acid molecules have dispersion forces between their chains. A greater number of atoms in a molecule results in more intense dispersion forces. 1 mark

As palmitic acid has the greatest number of atoms per molecule, it has the most intense dispersion forces, which require a higher temperature to disrupt them *(meaning it has the highest melting point)*. 1 mark

b.



2 marks

1 mark for showing the correct format and ester links.

1 mark for showing the correct semi-structural formula of palmitic acid.

Question 7 (9 marks)

a. $n(CO_2) = \frac{m}{M} = \frac{13.2}{44.0} = 0.3$ mol, so 0.1 mol of the compound contains 0.3 mol of carbon. 1 mark

$n(CH_4) = \frac{V}{V_m} = \frac{7.44}{24.8} = 0.3$ mol, $n(H) = 4 \times n(CH_4) = 4 \times 0.3 = 1.2$ mol, so 0.2 mol of the compound contains 1.2 mol of hydrogen *(0.1 mol of the compound contains 0.6 mol of hydrogen)*. 1 mark

$n(O) = \frac{N}{N_A} = \frac{5.42 \times 10^{23}}{6.02 \times 10^{23}} = 0.9$ mol, so 0.3 mol of the compound contains 0.9 mol of oxygen *(0.1 mol of the compound contains 0.3 mol of oxygen)*. 1 mark

For example, any one of:

- $n(C) : n(H) : n(O) = 0.3 : 0.6 : 0.3 = 1 : 2 : 1$. The empirical formula is CH_2O, which is the empirical formula of compound X, not compound Y (which has the empirical formula $C_3H_4O_2$).
- 0.2 mol of compound Y would have 0.8 mol of hydrogen, not 1.2 mol as calculated, so the information applies to compound X, not compound Y.
- 0.3 mol of compound Y would have 0.6 mol of oxygen, not 0.9 mol as calculated, so the information applies to compound X, not compound Y.

1 mark

b. *Any one of:*

- CH_3CHOH^+
- $COOH^+$

1 mark

Note: The base peak is at m/z = 45.

c. *For example:*

Compound X has a signal for both OH acid and OH alcohol, giving rise to a wide signal between 2500 and 3600 cm^{-1}. The signal at 3200 to 3600 cm^{-1} is narrower for compound Y as it only has OH acid. 1 mark

In compound Y's spectrum, there is a strong signal at 1620 to 1680 cm^{-1}, which relates to the double bond between the carbon atoms. Compound X does not have this signal. 1 mark

d. *For example:*

The sample can be mixed with bromine water. If the sample is compound Y, the brown-orange colour of the bromine water will clear as the bromine molecule is added across the double bond between carbon atoms in compound Y. 1 mark

If the sample is compound X, the colour will not clear because compound X does not have a double bond between carbon atoms. 1 mark

Question 8 (8 marks)

a. *Any one of:*

- solar energy using photovoltaic cells
- wind energy using a windmill and turbine

1 mark

b. *Any one of:*

- to keep the reactants separated from each other but in electrical contact
- to allow ion movement between the half-cells

1 mark

c.

	Oxidation	**Reduction**
Anode	$V^{2+}(aq) \rightarrow V^{3+}(aq) + e^-$	
Cathode		

2 marks

1 mark for writing the correct half-equation.
1 mark for selecting the correct box.

d. $VO^{2+}(aq) + H_2O(l) + V^{3+}(aq) \rightarrow VO_2^{+}(aq) + 2H^+(aq) + V^{2+}(aq)$

2 marks

1 mark for providing the correct reactants.
1 mark for providing the correct products.

e. The best classification is a hybrid of a fuel cell and a secondary cell. The battery is not a primary cell as the reactants are not used up; it is a secondary cell as its cell reactions are reversed by recharging using electrical energy. 1 mark

It can also be classified as a fuel cell as its reactants are fed continuously into the cell. 1 mark

Question 9 (14 marks)

a. **i.** the charge on metal ions **OR** the electrolyte 1 mark

ii. *Any two of:*

- current
- concentration of the electrolyte
- surface area of the electrode immersed in the electrolyte
- duration of electroplating
- temperature

2 marks
1 mark for each correct controlled variable.

b. **i.** The experiment is valid as the stated method provides results that may support or negate the hypothesis. 1 mark

In the experimental design, only one variable was altered for each trial and all other variables were kept constant. 1 mark

ii. *For example:*

The trial could be repeated several times to allow an average to be calculated. This is more reliable than a single result and so would minimise the effects of random error. 1 mark

Even though the anion in each electrolyte does not affect the deposition of each metal, the $SnCl_2(aq)$ could be replaced by $Sn(NO_3)_2(aq)$ to remove any doubt about the effect of the anion on the experiment. 1 mark

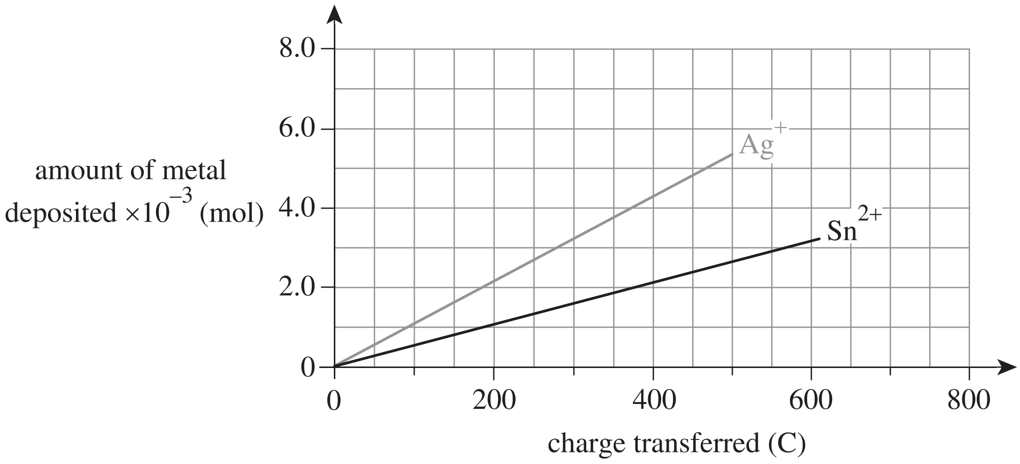
iii. A possible relationship could be drawn as the lowest charged ion (Ag^+) produced the highest mass (1.37 g) and the highest charged ion (Cr^{3+}) produced the lowest mass, 0.21 g. 1 mark

However, the results for the two doubly charged ions, Cu^{2+} and Sn^{2+}, ranged from 0.39 g to 0.87 g, respectively. This variation possibly suggests no correlation between ion charge and the mass of metal deposited. 1 mark

c. **i.** $n(\text{Ag}) = \frac{m}{M} = \frac{0.68}{107.9} = 6.3 \times 10^{-3}$ mol 1 mark

$Q = It = 2.00 \times 5.0 \times 60 = 600$ C 1 mark

ii.



1 mark

Note: Each value on the y-axis is halved for a given value on the x-axis.

iii. $Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$, so for each mole of silver produced, 1 mol of electrons is consumed. 1 mark

From the graph, 400 C of charge results in 4.2×10^{-3} mol of Ag being deposited.

So, 1 mol of silver requires $\frac{400}{4.2 \times 10^{-3}} = 95\,238 = 9.5 \times 10^{4}$ C. Therefore, this is the charge on 1 mol of electrons. 1 mark

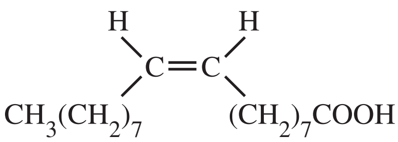
Note: Accept values in the range 9.2–9.8 × 10^{4} C based on reading from the graph.

Question 10 (9 marks)

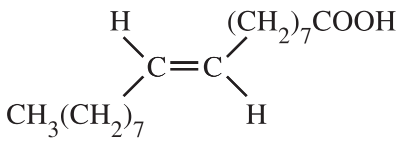
a. *Any one of the following descriptions of geometric isomerism:*

- Geometric isomerism occurs due to restricted rotation somewhere in a molecule, such as the carbon–carbon double bond in an unsaturated hydrocarbon chain in the fatty acid oleic acid.
- Geometric isomerism occurs when there are two different groups attached to each carbon atom in a carbon–carbon double bond. There are two possible arrangements of these groups: on the same or on opposite sides of the double bond.
- Any other appropriate description.

Geometric isomerism can be illustrated by cis- and trans- oleic acid.



cis-oleic acid

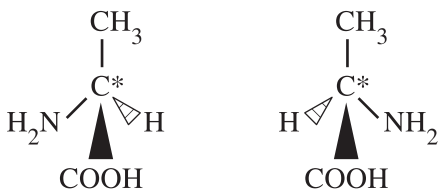


trans-oleic acid

Any one of the following descriptions of optical isomerism:

- In optical isomerism, two molecules have the same structural formula but different placement of groups around one atom in each molecule.
- In optical isomerism, the molecules are chiral. That is, they are mirror images of each other but are not superimposable on top of each other.
- In optical isomerism, at least one atom (the chiral centre) in each molecule has four different groups attached in a tetrahedral arrangement. The molecules have no planes of symmetry overall.
- Any other appropriate description.

Enantiomers (optical isomers) of alanine showing chiral centres illustrate optical isomerism.



*chiral centre

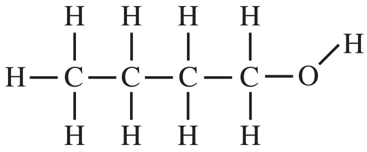
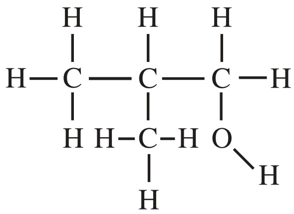
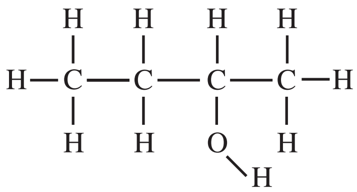
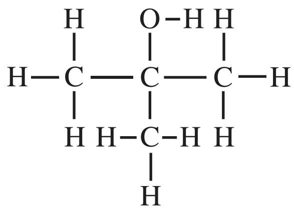
Any one of the following examples of the effect of stereoisomerism on a physical property:

- Different melting points of cis- and trans-isomers: cis-oleic acid has a lower melting point than trans-oleic acid. The cis configuration leads to more widely spaced molecules, which results in reduced strength of dispersion forces between the hydrocarbon chains *(leading to the lower melting temperature).*
- Rotation of plane polarised light by optical isomers: Enantiomers have identical physical properties with the exception that they rotate plane polarised light in opposite directions.
- Any other appropriate example.

5 marks

1 mark for describing geometric isomerism.
1 mark for drawing a diagram or providing a description of cis- and trans-oleic acid.
1 mark for describing optical isomerism.
1 mark for drawing a diagram or providing a description of alanine enantiomers.
1 mark for providing one example of the effect of one type of stereoisomerism on a physical property.
Note: Responses are not required to include diagrams of cis- and trans-oleic acid and alanine enantiomers if appropriate and sufficient descriptions are provided.

b. *For example, any two of the following butanol molecules.*

<table>
<tr><th>Drawing of molecule</th><th>Explanation of the nature of the structural isomerism</th><th>Difference in the chemical reactions</th></tr>
<tr><td>
butan-1-ol</td><td>This is a primary alcohol where the OH group is attached to a carbon that has only one other carbon atom attached to it.</td><td rowspan="2">This molecule is oxidised by strong oxidants such as acidified dichromate or acidified permanganate solutions, producing aldehydes and carboxylic acids.</td></tr>
<tr><td>
2-methylbutan-1-ol</td><td>This is a branched molecule and a primary alcohol where the OH group is attached to a carbon that has only one other carbon atom attached to it.</td></tr>
<tr><td>
butan-2-ol</td><td>This is a secondary alcohol where the OH group is attached to a carbon that has two other carbon atoms attached to it.</td><td>This molecule is oxidised by strong oxidants such as acidified dichromate or acidified permanganate solutions, producing ketones.</td></tr>
<tr><td>
2-methylbutan-2-ol</td><td>This is a branched molecule and a tertiary alcohol where the OH group is attached to a carbon that has three other carbon atoms attached to it.</td><td>This molecule is not oxidised by/has no reaction with strong oxidants such as acidified dichromate or acidified permanganate solutions.</td></tr>
</table>

4 marks

1 mark for each correctly drawn butanol isomer.
1 mark for describing the nature of the structural isomerism shown by the two isomers.
1 mark for describing the difference in chemical reactions of the two isomers.
Note: A table and the names of the butanol isomers are not required to obtain full marks.
Responses should not compare butan-1-ol and 2-methylbutan-1-ol as they have very similar chemical reactions.