VICTORIAN CURRICULUM
AND ASSESSMENT AUTHORITY

VICTORIA State Government

2021 VCE Chemistry (NHT) examination report

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A

The following table indicates the correct answer, and the percentage of students who chose each option.

Question	% A	% B	% C	% D	N/A	Comment
1.	0	88	8	4	0	
2.	24	32	40	4	0	Cations move to the cathode, the site of reduction.
3.	36	4	36	20	4	Side reactions will reduce battery life since the amounts of available reactants are reduced. Discharge is a galvanic process. Battery life is affected by temperature variation, but impact is not directly proportional to temperature. Voltage is higher during recharge.
4.	16	68	12	4	0	Protein is denatured, so the secondary and tertiary structures are affected but **not** the primary structure.
5.	16	76	4	0	4	Larger surface area of iron pieces results in higher reaction rate.
6.	80	0	0	20	0	At pH 4, acidic solution, the amino acid is protonated – acts as a base and accepts a proton – and assumes an overall positive charge.
7.	28	24	28	20	0	Smaller volume of water added for the reaction results in **greater change in temperature**. Hence the calculated energy (E = CF x ΔT) is larger, resulting in a **higher molar heat** of solution (E / n)
8.	8	28	60	4	0	Biodiesel molecules are polar and larger than petrodiesel and petrol molecules, and so have the strongest intermolecular attraction hence highest viscosity. Whilst ethanol molecules are polar and have intermolecular hydrogen bonding, they are also much smaller than petrol molecules and so the overall attraction is the lowest of the four options and so it has the lowest viscosity.
9.	8	16	28	48	0	The term ‘titrated against’ in this question implies that the 0.30 M NaOH(aq) was in a 50.0 mL burette and 23.65 mL of this solution was required to reach the endpoint when added to the titration flask containing the acid.

Question	% A	% B	% C	% D	N/A	Comment
						Whilst the *n*(acid) can be calculated (0.050 x 23.65x10^{-3}) its concentration cannot because the volume of acid in the titration flask is not given. No information is provided re redox reactions. Phenolphthalein changes colour at a higher pH than methyl red. Since the base is being added to the acid the endpoint would occur later so the titre volume would be larger. If 0.10 M NaOH was used the titre volume would be approximately 23.65 x 3 = 70.95 mL. This larger titre volume may reduce the impact of random errors, so the results would be more precise. However, the impact of needing to refill the burette will also have an impact. Hence since precision **may** be increased and since the other alternatives are incorrect, the best alternative is D.
10.	0	8	64	28	0	
11.	68	12	20	0	0	-OH group has higher priority than -NH_2 group, hence -OH is on C-1 of a 4-C chain with -NH_2 group on C-3.
12.	12	56	20	12	0	To be oxidised the alcohol must have -CH_2OH which is oxidised to -COOH
13.	16	60	16	8	0	100 g fuel: 90 g C_8H_{18} + 10 g CH_3CH_2OH Energy from 100 g = 90 x 47.9 + 10 x 29.6 = 4607 kJ Energy from 1 g = 46.07 kJ *m*(fuel) = 2396x10^3 / 46.07 = 5.2x10^4 g = 5.2x10^1 kg = 5.2x10^{-2} t
14.	36	8	36	20	0	*n*($CaCO_3$) = 0.34 / 100 = 3.4x10^{-3} mol *n*(HCl) = 0.50 x 12.0x10^{-3} = 6.0x10$^{–3}$ Since 3.4x10^{-3} mol $CaCO_3$ required 6.8x10^3 mol HCl for complete reaction, *V*(CO_2) levels out when the acid has completely reacted
15.	28	20	32	16	4	*n*(KOH) in 20 ml titre = 0.102 x 20x10^{-3} = 0.00204 mol *n*(CH_3COOH) in 20 mL diluted = 0.00204 mol *m*(CH_3COOH) in 100 mL = 5 x 0.00204 x 60 = 0.612 g in 100 mL i.e. 0.612 % m/V So, vinegar has to be diluted by a factor of 3.16 / 0.612 = 5.2 Dilute 20 mL original sample to 100 mL
16.	16	24	36	20	4	Since Hb has a greater affinity for CO than for O_2, the equilibrium position for Reaction 2. lies further to the left so $K_2 < K_1$ CO binds more readily to Hb Increased levels of CO push Reaction 2. to the left. The decrease in [Hb] impacts in Reaction 1. pushing it to the right, i.e., favouring the forward reaction.
17.	8	24	52	12	4	In each cell pair the redox pair with the higher E^0 is located in the half-cell containing the cathode, i.e., the half-cell towards which cations are moving.

Question	% A	% B	% C	% D	N/A	Comment
						Hence the order of the redox-pairs in terms of decreasing oxidising agent strength / increasing reducing agent strength is IO_3^-(aq)/I_2(aq) I_2(aq)/I^-(aq) Sn^{4+}(aq)/Sn^{2+}(aq) Strongest oxidising agent – IO_3^-(aq), strongest reducing agent Sn^{2+}(aq)
18.	16	16	20	44	4	IO_3^-(aq) is reduced to I_2(aq) $2IO_3^-(aq) + 12H^+(aq) + 10e^- \rightarrow I_2(aq) + 6H_2O(l)$ I^-(aq) is oxidised to I_2(aq), not IO_3^-
19.	36	40	16	8	0	$CH_3COOCH_2CH_3$; $CH_3CH_2COOCH_3$; $HCOOCH_2CH_2CH_3$;
20.	16	28	32	20	4	Forward, dissociation of I_2, and reverse reactions continue at the same rates.
21.	4	36	12	44	4	Both compounds have very similar molar masses and are polar due the presence of the O-H and N-H bonds respectively. However, the N-H bond is less polar than the O-H bond so the intermolecular bonding will be stronger in hexan-1-ol so it has the higher boiling point. Since both molecules have similar molar masses and non-polar regions, the impact of intermolecular dispersion force attraction is less significant.
22.	8	12	56	20	4	Energy from ethanol = 0.720 g x 29.6 kJ g^{-1} = 21.3 kJ Expected ΔT for 500 g of water = $21.3 \text{x} 10^3$ / (4.18 x 500) = 10.2 °C Best explanation was that the **stirrer was not working**. Whilst a higher ΔT would be expected for 450 g, it would not be as high as 22 °C. If ethanol had escaped the ΔT would be smaller not greater.
23.	12	40	32	12	4	Energy from food = (0.63 x 1.5 x37) + (0.37 x 1.5 x 17) = 44.4 kJ ΔT = 44 kJ / 1.67 kJ $°C^{-1}$ = 27 °C
24.	28	12	36	24	0	Activation energy is defined as the minimum energy needed for a reaction to occur and in this question it is represented on an energy profile for the reaction equations with the simplest whole number ratios of reactants and products. The amount of energy involved can be calculated as the difference of the energy at the top of the profile and the energy of the reactants. According to the profile provided. E_a = 27 kJ for Y + 2Z $\rightarrow$ 3X + W 1. E_a = 17 kJ for 3X + W $\rightarrow$ Y + 2Z 2. In effect the ‘energy barrier’ (minimum energy needed for reaction to occur) is being considered. It can be concluded that the energy barrier for the reaction in which

Question	% A	% B	% C	% D	N/A	Comment
						A. 1 mol W is produced is 27 kJ B. 1 mol Z is produced is 17/2= 8.5 kJ C. 0.5 mol X is produced is 27/6 = 4.5 kJ D. 9 mol Y is produced is 9x17 = 153 kJ However, since the activation energy is lower in the presence of a catalyst the respective energy barriers are A. < 27 kJ; B. < 8.5 kJ; C. < 4.5 kJ; **D < 153 kJ**. Hence the best alternative is D.
25.	36	20	8	36	0	A. Y would be an ester B. Y would be $CH_3CONHCH_2CH_3$ C. No reaction D. $CH_3COOH + CH_3NH_2 \rightarrow$ **$CH_3CONHCH_3$**
26.	0	44	20	32	4	Both $CO_2(g)$ and $H_2O(g)$ are greenhouse gases.
27.	40	16	12	32	0	Chloromethane, CH_3Cl is the most polar molecule – strongest attraction to the polar mobile / solvent hence lowest retention time. It is also the smallest molecule and hence has the weakest attraction to the non-polar stationary phase.
28.	16	20	20	40	4	The positive electrode, to which electrons move through the external circuit, is the site of reduction. The only product at this electrode is CO_3^{2-}
29.	40	20	24	12	4	
30.	8	12	16	64	0	

Section B

Question 1a.

Correct answer: glycogen.

Question 1bi.

Correct answer:

A peptide bond joins the amino acids together

or

a peptide bond forms the linkages in the primary structure.

Also correct: Peptide links are essential for the formation of the secondary structure.

Question 1bii.

Correct answer:

Each protein has a unique sequence of amino acids / each protein has a structure determined by its different amino acids / primary structure.

Question 1c.

Two or more polypeptide (protein) subunits (molecules or chains) are assembled into a particular arrangement to make a protein.

The quaternary structure is held together by the intermolecular bonding (e.g., dispersion forces, etc.) between the side chains (R groups) of the subunits.

Students were awarded 1 mark for multiple subunits and 1 mark for specifying the type of bonding between the side chains.

Question 1d.

Induced fit – substrate joins at the active site, the enzyme and substrate interact through weak bonds, altering the shape of the active site.

After reaction the active site returns to its original shape.

The enzyme provides an alternative reaction pathway which lowers the activation energy.

Students were awarded 1 mark for describing how the active site of the enzyme changes shape to fit the substrate and 1 mark for any of the following:

- lowering the activation energy
- providing an alternative reaction pathway
- after reaction, active site returns to original shape.

Question 1e.

A co-enzyme:

- changes the shape of the active site to accept the substrate
- can act as carrier for electrons or groups of atoms.

Question 2a.

Any one of the following is correct:

- $C_3H_8(g) + 7/2\ O_2(g) \rightarrow 3CO(g) + 4H_2O$
- $2C_3H_8(g) + 7O_2(g) \rightarrow 6CO(g) + 8H_2O$

Question 2b.

V(propane gas) = 17.00 / 2 = 8.50 L

p = 883 kPa, T = 27.0 °C = 300 K

n(propane gas) = pV/RT

= 883 × 8.50 / (8.31 × 300)

= 3.01 mol

m(propane gas) = 3.01 × 44.0

= 132 g

V(propane liquid) = 8.50 L

m(propane liquid) = density x volume

= 489.3 g L^{-1} × 8.50 L

= 4.16 × 10^3 g (4159)

Total mass of propane = 132 + 4159 g

= 4291g

= 4.3 kg (4.29)

Students were awarded:

- 1 mark for the correct number of moles of propane gas
- 1 mark for the correct mass of propane gas
- 1 mark for the correct mass of propane liquid
- 1 mark for the correct total mass of propane in kg.

Question 2c.

Propane and butane are both nonpolar molecules, however propane molecules are smaller than butane molecules, so propane has weaker dispersion forces between its molecules.

Therefore, propane gas is more easily vapourised than butane gas and therefore will undergo combustion / burn more readily in colder temperatures.

Students were awarded:

- 1 mark for the relative size of molecules and the relative strength of dispersion forces.
- 1 mark for propane gas is more easily vapourised.

Question 3a.

There are no stereoisomers of but-3-en-1-ol existing.

There are no cis-trans isomers as there are two hydrogens on one of the carbons in the double bond There is no chiral centre, meaning that there are no enantiomers.

Students were awarded:

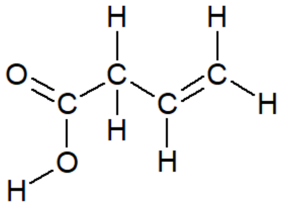
- 1 mark for no stereoisomers
- 1 mark for no chiral centre and no cis-trans isomers.

Question 3b.

Any one of the following is correct:

- $KMnO_4/H^+$
- MnO_4^-/H^+
- $Cr_2O_7^{2-}/H^+$
- $K_2Cr_2O_7/H^+$.

Question 3c.



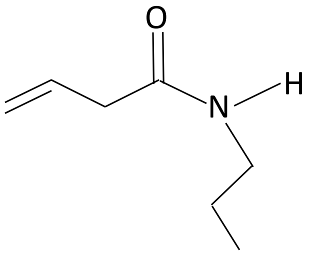
Question 3d.

Correct answer: Substitution reaction.

Question 3e.

Correct answer: $CH_3CH_2CH_2NH_2$

Question 3f.



Students were awarded:

- 1 mark for the correct atoms and bonds
- 1 mark for the correct representation in skeletal formula form.

Question 4a.

Energy in 42.1 g of carbohydrates = 42.1 g × 16 kJ g^{-1}

= 670kJ

Only 20% of carbohydrate is soluble, so

Accessible energy = 670 × 0.20

= 135 kJ (134.72)

Energy from 16.5 g of protein = 16.5 × 17

= 280.5 kJ

Energy from 29.48 g of fat = 29.48 × 37

= 1091 kJ (1090.76)

Total energy per 100 g of food = 280.5 + 134.7 + 1090.8

= 1500 kJ (1.5×10^3 kJ)

Students were awarded:

- 1 mark for the correct amount of energy from the 20% of carbohydrates that can be digested
- 1 mark for the correct total energy.

Question 4b.

As amylose is a linear molecule, the unbranched chains are very closely packed together. This makes it more difficult for amylose to hydrolyse to glucose.

Question 4c.

Correct answer: Provides essential fatty acids that the body cannot produce.

Question 4d.

Students were awarded 1 mark for each of the following:

- $3H_2O$
- $3C_{17}H_{29}COOH$ / $C_{18}H_{30}O_2$

Question 4e.

The position of the C=C bond is counted from the $–CH_3$ end (omega end) of the fatty acid. Hence the C=C starts at the third carbon (C_3) for the omega-3 fatty acid and at the sixth carbon (C_6) for the omega-6 fatty acid.

Question 4f.

Vitamin C is a polar molecule that has 4 hydroxyl functional groups (OH groups), which can form hydrogen bonds with water.

Vitamin D is essentially a non-polar molecule (only 1 hydroxyl group) that has a non-polar carbon chain making it insoluble in water, but soluble in fats.

Students were awarded:

- 1 mark for a correct reason Vitamin C is water soluble.
- 1 mark for a correct reason Vitamin D is insoluble in water / soluble in fat.

Question 5a.

Correct answer: (+) / positive

Question 5b.

Students were awarded one mark for each of the following:

- The platinum metal falls to the bottom of the cell / collects under the positive electrode
- Platinum is a weaker reductant than the copper, so the copper is preferentially oxidised to Cu^{2+}, and goes into solution, leaving the solid Pt particles to drop down.

Question 5c.

Correct answer: $Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$

Question 5d.

Cu^{2+} migrates to the cathode where reduction occurs as Cu^{2+} is the strongest oxidant.

The migration of Cu^{2+} to the cathode (-) and sulfate ions to the anode (+) prevents the build-up of charge at each electrode.

Copper (II) sulfate contains $Cu^{2+}(aq)$, which is involved in the two half-reactions, and sulfate ions which do not react under the reaction conditions.

Students were awarded:

- 1 mark for the movement or action of Cu^{2+} ions
- 1 mark for the movement or action of sulfate (SO_4^{2-}) ions or recognition that sulfate ions are inert in this situation.

Question 5e.

m (Cu) = 356.0 × 0.994

= 353.9 g

n(Cu) = 353.9/63.5

= 5.57 mol

n(e^-) = 2 × 5.573

= 11.1 mol

Q = 11.1 × 96500

= 1.076 ×10^6 C (1075524C)

$t = Q / I$ = 1075524 / 2.00

= 537762 seconds

= 537762 / 3600 hours

= 149 hours

Students were awarded:

- 1 mark for correctly calculating *n*(Cu)
- 1 mark for correctly calculating n(e^-)
- 1 mark for correctly calculating Q
- 1 mark for correctly calculating t in hours to 3 significant figures.

Question 6a.

Kc = $[SO_3]^2 / [O_2][SO_2]^2$

Initial $[SO_2]$ = 1.0 M; initial $[O_2]$ = 1.0 M

$\Delta[O_2]$ = 1.0 – 0.32 M = 0.68 M

$[SO_2]_e$ = 2.0 M – 2 × 0.68 M

= 0.64 M

$[SO_3]_e$ = 2 × 0.68 M = 1.36 M

$[O_2]_e$ = 0.32 M

$[SO_2]_e$ = 0.64 M $[SO_3]_3$ = 1.36 M

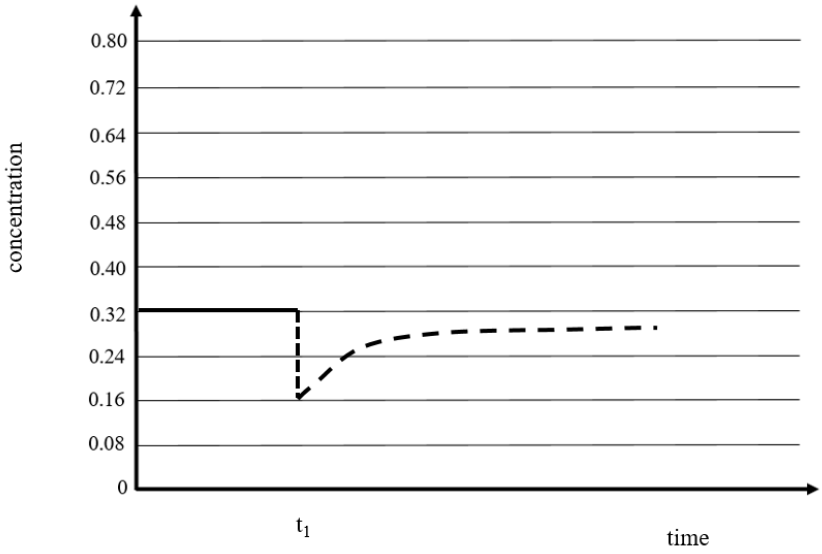
K_c = $1.36^2/(0.32 \times 0.64^2)$

= 14 M^{-1}

Students were awarded:

- 1 mark for the correct equilibrium law expression
- 1 mark for all equilibrium concentrations correct
- 1 mark for correct Kc with correct unit.

Question 6bi.



Students were awarded:

- 1 mark for the concentration halving to 0.16 M at t1
- 1 mark for the concentration increasing as system moves to new equilibrium after the change i.e., from 0.16 M and reaching equilibrium below 0.32 M.

Question 6bii.

The concentration halves at t_1 and then increases as the reaction tries to oppose the change by moving to the side with more particles / equilibrium moves to the left. This results in an increase of [O_2].

Students were awarded:

- 1 mark for initial change
- 1 mark for moving to the side with more particles

Question 6biii.

Since the temperature stays the same the likelihood of a collision being successful (fraction of collisions that are successful) is the same but the frequency of collisions and consequently the frequency of collisions that are successful reduces due to the halving of the concentration.

So, the rate of the forward reaction will decrease.

As the system returns to equilibrium the [O_2] and [SO_2] increase so the rate of the forward reaction increases. However, the rate at the new equilibrium will be less than at the initial equilibrium.

Students were awarded:

- 1 mark for reduced frequency of collisions and successful collisions due to reduced concentration
- 1 mark for decreased rate of forward reaction.

Question 7a.

$Zn(s) + H_2O(l) \rightarrow ZnO(s) + H_2(g)$

Question 7b.

$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$

Question 7c.

Correct answer: Arrow pointing to the left.

Question 7d.

The amount of H_2 produced in the generator cell is equal to the amount of H_2 consumed in the fuel cell.

The half-equations show that n(e^-) released (2 per mol H_2 produced) in the generator cell is equal to the n(e^-) used (2 per mol H_2 consumed) in the fuel cell.

Two electrons are transferred in the production of each mole of hydrogen in the Zn-H_2 generator cell and two electrons are transferred in the reaction of each mole of hydrogen consumed in the hydrogen fuel cell.

Students were awarded:

- 1 mark for the correct explanation of the mass (mole) balance
- 1 mark for the correct explanation for electron balance

Question 7e.

Oxygen is a stronger oxidant than H_2O, so would be reduced at the cathode.

$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ would occur at the cathode and no H_2 would be produced.

The reduction of O_2 is higher on the electrochemical series, so water will not be reduced, and hydrogen will not be produced.

Students were awarded:

- 1 mark for the half-equation for the reduction of O_2
- 1 mark for the correct explanation.

Question 7f.

Zn-H_2 generator cell converts chemical energy of zinc to electrical energy **and** chemical energy in the form of hydrogen.

H_2 fuel cell converts chemical energy of hydrogen to electrical energy

Students were awarded:

- 1 mark for the correct conversion for the Zn-H_2 generator cell
- 1 mark for the correct conversion for the H_2 fuel cell

Question 8ai.

Correct answer: 41.

Question 8aii.

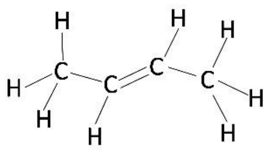
Correct answer: C_4H_8

Question 8aiii.

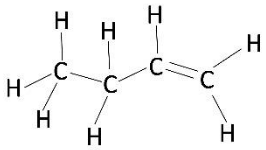
Correct answer: $[C_3H_5]^+$

Question 8b.

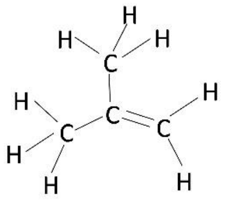
Students were awarded a maximum of two marks – one mark for each of two correct structures from four options – but-2-ene (*cis* or *trans*), but-1-ene, methylpropene, cyclobutane (names not required).



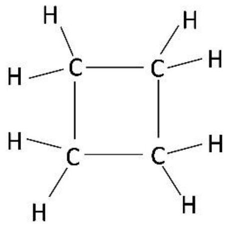
but-2-ene (*trans* form)



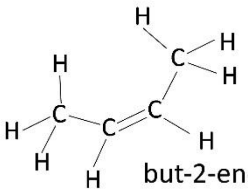
but-1-ene



methylpropene



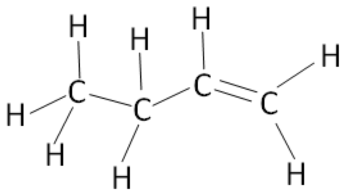
cyclobutane



but-2-ene (*cis* form)

Students were awarded a maximum of two marks – one mark for each of two correct structures from four options (names not required).

Question 8ci.



Question 8cii.

1-bromobutane

Question 8d.

The spectrum is Y.

Hydration of butene produces an alcohol and only Y shows an O-H absorption (3200-3600 cm^{-1}).

Y has absorption peaks for the O-H (alcohol) bond (3200-3600 cm^{-1}) and the C-H bonds (2850-3090 cm^{-1}).

Question 9a.

Possible controlled variables included:

- concentration of I_2
- same mass of pineapple juice in each of 9 conical flasks
- storage time of one day for each sample between analyses
- using a set temperature to store each sample
- same source of pineapple juice

Question 9b.

The dependent variable is the stability of ascorbic acid in pineapple juice/concentration of ascorbic acid in juice / $V(I_2)$.

It is measured by determining how the concentration of the ascorbic acid in the pineapple juice decreased over time / Titre volume, $V(I_2)$, changes with time.

Question 9c.

Repeat the titration until concordant titres are obtained in Part B step 6

Using 9 samples (to measure the effect of 3 different temperatures every 24 hours over three days) in part C.

Question 9d.

Average titre = (27.27 + 27.35 + 27.32) / 3 = 27.31 mL

$n(I_2) = c \times V \quad = 2.50 \times 10^{-4} \times 0.02731$ L

$= 6.828 \times 10^{-6}$ mol

$n(C_6H_8O_6) = n(I_2) = 6.828 \times 10^{-6}$ mol

$m(C_6H_8O_6) = n \times M_m \quad = 6.828 \times 10^{-6} \times 176.0$

$= 0.001202$ g (in 5.00 g of juice)

$c(C_6H_8O_6) = 0.001202 \times 20 = 0.0240$ g per 100 g of juice

$= 24.0$ mg / 100 g

Students were awarded:

- 1 mark for the correct concordant titre value
- 1 mark for the correct number of moles of $C_6H_8O_6$
- 1 mark for the correct answer in mg / 100 g.

Question 9e.

Trials 2, 4 and 5 are precise, as they are in a range of 0.1 mL.

or

Trials are not precise because of the titre range from 28.65 to 27.12 mL is greater than 0.1 mL variation.

Question 9f.

As temperature increases, the [$C_6H_8O_6$] decreases because more has reacted, indicating that ascorbic acid is less stable at higher temperatures

Question 9g.

Plot concentration against time with 3 different temperature graphs on the same axis.

Graph of concentration versus time shows the rate of change of concentration, which illustrates stability.

or

Plot ‘Rate of decrease of ascorbic acid concentration at each temperature’ against temperature. This illustrates stability.

Question 10a.

Possible responses included the following.

The overall equation that occurs when glucose is oxidised to form gluconic acid is:

$$2C_6H_{12}O_{6\,(aq)} + O_{2\,(g)} \rightarrow 2C_6H_{12}O_{7\,(aq)}$$

Glucose is only partially oxidised to gluconic acid, so the chemical energy in glucose is utilised very inefficiently / low percentage of available energy is accessed.

The respiration equation is:

$$C_6H_{12}O_{6\,(aq)} + 6O_{2\,(g)} \rightarrow 6CO_{2\,(aq)} + 6H_2O_{(l)}$$

Glucose is fully oxidised in respiration to form carbon dioxide, so its chemical energy is utilised very efficiently.

The oxidation number of carbon in glucose is 0, in gluconic acid it is +⅓, and in carbon dioxide it is +4.

Therefore, the chemical energy available from glucose is used efficiently in respiration, but inefficiently in a glucose fuel cell.

The relative number of electrons released per molecule of glucose – 2 in the fuel cell but 24 in respiration – $C_6H_{12}O_{6\,(aq)} + 24OH^-_{(aq)} \rightarrow 6CO_{2\,(aq)} + 18H_2O_{(l)} + 24e^-$ reflects the relative utilisation of available energy.

Since there is a 2-electron transfer for incomplete oxidation of glucose in fuel cell and a 24-electron transfer for complete oxidation in respiration, the efficiency of energy utilisation for the implant is 1/12 of that of the biological process.

Students were awarded:

- 1 mark – efficiency of utilisation comparison related to partial or complete oxidation of glucose
- 1 mark – fuel cell equation linked to low utilisation efficiency
- 1 mark – respiration equation linked to high utilisation efficiency

Second and third marks linked number of electrons in the half equations, or the changes in oxidation number.

Question 10bi.

Possible points include the following:

- Both convert chemical energy to electrical energy.
- Both use a continuous supply of reactants.
- The implantable fuel cell needs to be made from biocompatible materials (not dangerous to the human body) whereas the external fuel cell does not.
- The oxygen in the implantable fuel cell is aqueous whereas the oxygen in the external fuel cell is gaseous.
- The $C_6H_{12}O_7$ product of the reaction of an implantable fuel cell can be directly used by the body for energy, whereas the external fuel cell uses the available energy from glucose inefficiently.
- The concentration of the reactants in the implantable fuel cell is much lower than the concentration of the reactants in an external fuel cell.

Students were awarded 1 mark for each relevant point (up to a total of 2).

Question 10bii.

Students were awarded 1 mark each for the following:

- Difficulties in separating the two half cells (oxidant and reductant), given both reactants are present in blood.
- This is a problem because if the glucose and oxygen come into contact, they could react directly, and then electrical energy would not be produced / Electrical energy is only produced if oxidation and reduction occur at separate electrodes.

A further mark was given for one of the following:

- Membranes could act as barriers at the cathode and the anode allowing oxygen through but not glucose and glucose through but not oxygen respectively. This would stop oxygen and glucose reacting directly at the cathode.
- Use catalysts at the electrodes that only permit the required reactions to occur and do not catalyse the direct reaction of glucose with oxygen. (electrode choice and design)
- Set the half-cell up so that the fluids pass through the cathode before reaching the anode. This way there is very little oxygen left to react directly with the glucose once the fluid reaches the anode.

Alternative answers:

- The implantable fuel cell may not be biocompatible
- The materials being used may cause an adverse effect on the surrounding tissue, for example, the fuel cell starts to corrode and poisons the blood.
- This could be rectified by using corrosion proof plating such as gold or high-quality stainless steel.