

MCQ

1. B

In the electroplating process, the metal cations (in this case, Au^+ ions) are reduced at the **cathode** (the iron sheet) to form solid gold, which plates the surface. The **anode** (made of gold) typically dissolves, replenishing the Au^+ ions in the solution, but the movement of Au^+ ions toward the cathode, where they gain electrons and are reduced to solid gold.

[Link](#) to further reading

2. B

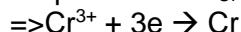
Step 1 Calculate the mol of Cr produced

$$\Rightarrow 4.12\text{g} / 52.0\text{g/mol} = 0.0792 \text{ mol}$$

Step 2 Calculate the mol of electrons

$$\Rightarrow 0.238 \text{ mol}$$

Step 3 ratio of $n_{\text{Cr}} : n_{\text{e}} \Rightarrow 0.0792 : 0.238 \Rightarrow 1 : 3$



[Link](#) to further reading on Faraday's Law

3. C

Step 1 Calculate the charge per second

The charge (Q) passing per second is given by:

$$Q = I \times t = (1.8 \times 10 \text{ A}) \times 1 \text{ s} = 1.8 \times 10^{-6} \text{ C}$$

Step 2 Calculate the mol of electrons.

$$\Rightarrow 1.8 \times 10^{-6} / 96500 = 1.87 \times 10^{-11} \text{ mol}$$

Step 3 According to the equation $\text{Zn}^{2+} + 2\text{e} \rightarrow \text{Zn}$

$$\Rightarrow \text{mol of Zn formed} = 1.87 \times 10^{-11} / 2 = 9.35 \times 10^{-12}$$

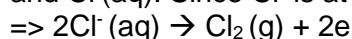
Step 4 Calculate the mass of Zinc

$$\Rightarrow 9.35 \times 10^{-12} \times 65.4 = 6.11 \times 10^{-10} \text{ grams}$$

[Link](#) to further reading on Faraday's Law

4. B

The possible candidates (reductants) that can react at the anode are $\text{I}^-(\text{aq})$, $\text{H}_2\text{O}(\text{l})$ and $\text{Cl}^-(\text{aq})$. Since Cl^- is at a concentration of 2M it will be oxidised at the anode.



[Link](#) to further reading on electrolysis

5. D

Use a molten electrolyte to avoid the production of gases (like H_2) at the cathode and to ensure that potassium ions are reduced at the cathode. A **molten** form of KCl is necessary because potassium is highly reactive and would react with water if an aqueous solution were used.

Choose an anode that is resistant to oxidation. In this case using Fe will cause the oxidation of the anode as it is the strongest reductant present. In fact it is the anode. **Carbon rods** are typically used as anodes in industrial electrolysis because they are inert and resist oxidation better than metals like iron, which would corrode over time.

[Link](#) to further reading on electrolysis

Link to biofuels for further reading for Q 6-8

[Lesson](#) (Video worksheet- introduction to fuels- Part 1) ([Video](#) – fuels part 2)

6. B
Fuel B has the lowest iodine number, which indicates it has the fewest unsaturated bonds and is therefore less prone to oxidation compared to A and C.
7. C
Given the need for a compromise between stability and cold flow, **Fuel C**, with an iodine number of 136, represents a middle ground. It has better cold flow properties than Fuel B and is less prone to oxidative degradation than Fuel A. Thus, the best choice for remote Northern hemisphere cold climates would indeed be Fuel C.
8. D
lets look at every option as this provides a nice revision for the topic of biofuels.
- a) is incorrect. While Fuels A and C have higher iodine numbers, indicating they are more unsaturated, this statement is misleading. The heat of combustion for all fuels is given as 45 kJ/g, suggesting that their energy content per gram is the same. Given that all fuels have the same number of carbons in a straight chain, we cannot definitively state that A and C have less energy per mole than B based solely on the information provided.
- b) Is incorrect. This statement is not true because biodiesel is typically produced via transesterification of triglycerides, not hydrolysis. Hydrolysis would lead to the formation of glycerol and fatty acids, not biodiesel.
- c) Is incorrect. While van der Waals forces (dispersion forces) are present in all hydrocarbons and biodiesel, they also exhibit dipole-dipole interactions due to the polar nature of their ester bonds and the presence of functional groups. Therefore, it is inaccurate to state that they have only van der Waals forces.
- d) Is correct. The concept of a circular economy involves utilizing renewable resources, minimizing waste, and ensuring that products can be recycled or reused. Biodiesel, being derived from biological materials (like oils and fats), supports sustainability and resource efficiency, fitting the circular economy mode
9. C
According to the balanced chemical equation

$$\text{Atom Economy} = (\text{mass of desired product} / \text{total mass of reactants}) \times 100$$
$$\Rightarrow (6.0 / 34.0\text{g}) \times 100 = 17.6\%$$

Two links below to further reading on atom economy

[Video worksheet](#) - Atom economy and percentage yield.

[Video worksheet](#) - Atom economy and percentage yield with two step reactions.

10. A

Step 1 Calculate moles of methane (CH₄)

$$\Rightarrow 1.60 \text{ g} / 16.0 \text{ g/mol} = 0.100 \text{ mol}$$

Step 2 Use stoichiometry to find theoretical yield of H₂

$$\Rightarrow \text{mol of H}_2 \text{ formed} = 0.100 \times 3 = 0.300$$

$$\Rightarrow \text{theoretical mass of H}_2 = 2 \times 0.300 = 0.600 \text{ g}$$

Step 3 Calculate percentage yield

$$\Rightarrow (0.500 / 0.600) \times 100 = 83\%$$

[Video worksheet](#) - Atom economy and percentage yield.

[Video worksheet](#) - Atom economy and percentage yield with two step reactions.

11. B

Atom economy measures how well a chemical reaction incorporates all reactant atoms into the desired product, minimizing waste. Percentage yield indicates the efficiency of converting reactants into the product, but doesn't account for how much waste is produced.

12. D

Step 1 Calculate the mol of nitrogen gas formed. We could $PV = nRT$ or SLC since the pressure is 100 kPa and the temperature is 25°C.

$$\Rightarrow \text{Using SLC} \Rightarrow \text{mol of nitrogen gas} = 45.0 / 24.8 = 1.81 \text{ mol}$$

Step 2 calculate the mol of azide

$$\Rightarrow 1.81 \times 10/16 = 1.13$$

Step 3 calculate the mass of azide

$$\Rightarrow 1.13 \times 65.0 = 73.7 \text{ grams or } 74\text{g}$$

13. B

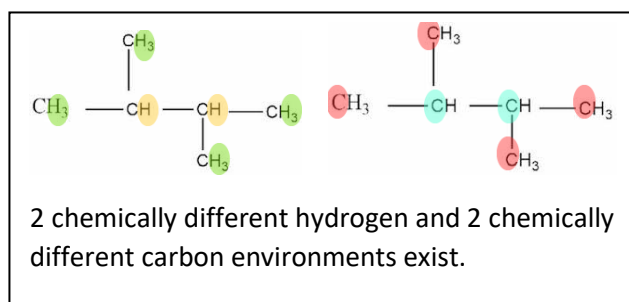
Due to symmetry 2,3-dimethylbutane has.

¹H NMR: 2 peaks.

¹³C NMR: 2 peaks

Keep in mind that chemically identical hydrogens do not split each others signal. ¹³C NMR only has singlets and no splitting due to the fact that ¹³C is rare and unlikely it will have another ¹³C as a neighbour to split the signal.

[Link](#) to further reading on ¹H NMR



14. D

Increase in temperature: If the forward reaction is endothermic, increasing the temperature will favour the forward reaction more than the reverse reaction. Both rates increase, but the forward rate increases significantly until equilibrium is re-established.

Concentration change: If more of reactants A or B are added, the forward rate would initially increase more as the system tries to restore equilibrium by forming more product (C). However this was not an option.

Even though rate vs time graphs are not on the study design examiners can provide you with a graph and ask you to determine the stress put on the equilibrium system. [Here](#) is another example with solutions.

15. C

Total before bond formation = $89 + 121 + 75 = 285$ g/mol

Subtract the mass of two water molecules (36 g/mol): $285 - 36 = 249$ g/mol

Therefore, the molecular mass of the tripeptide is closest to 249 g/mol.

16. D

[Link](#) to further reading on chiral centres.

17. C

Step 1 Calculate the initial concentration of phosgene (COCl_2).

$$\Rightarrow \text{Mol of phosgene} = 9.9 \text{ g} / 98.9 \text{ g/mol} = 0.10 \text{ mol}$$

$$\Rightarrow \text{The concentration of phosgene} = 0.10 / 2.00 = 0.050 \text{ M.}$$

Step 2 Set up an ICE table.

Species	Initial (M)	Change (M)	Equilibrium (M)
COCl_2	0.050	-0.042	$0.050 - 0.042$
CO	0	+0.042	0.042
Cl_2	0	+0.042	0.042

$X = 0.042$ as per problem

$$K_c = [0.042][0.042] / [0.0080] = 0.22\text{M}$$

[Link](#) to further problems using ICE tables.

18. C

Step 1 Lets use ICE tables.

Species	Initial (M)	Change (M)	Equilibrium (M)
H ₂	1.00	-x	1.00 - x
I ₂	1.00	-x	1.00 - x
HI	0	+2x	2x

Step 2 Write the expression for the equilibrium constant and solve for x

$$K_c = 4x^2 / (1.00-x)^2 = 49$$

$$\Rightarrow 2x / (1.00 - x) = 7$$

$$\Rightarrow 2x = 7.00 - 7x$$

$$\Rightarrow x = 7/9 = 0.778$$

Step 3 find [H₂]

$$\Rightarrow 1.00 - 0.778 = 0.222 \text{ M}$$

[Link](#) to further problems using ICE tables.

19. D

Since the number of gas molecules on both sides of the equation is the same (2 moles on both sides), a change in pressure (due to a decrease in volume) will have no effect on the equilibrium position. The system cannot reduce the pressure by shifting to the side with fewer moles of gas because both sides have the same number of moles

Further reading.

[Lesson 3](#) Changes to a system at equilibrium [Solutions](#)

20. A

Analysing the options:

- As the reaction is exothermic (ΔH negative), increasing temperature would shift the equilibrium to the left (favoring reactants), resulting in more H₂ and I₂ and a decrease in HI.
- If an inert gas is added the concentrations of the gases involved in the reaction would not be affected and thus wouldn't cause a decrease in I₂.
- A volume decreases would decrease will have no significant effect on the equilibrium position since moles are equal on both sides.
- The decrease in I₂ can best be explained by the addition of a substance that reacts with HI thus driving the equilibrium towards the formation of product.

Links to further reading on equilibrium.

[Video](#) summarising Qc and Kc

[Lesson 3](#) Changes to a system at equilibrium [Solutions](#)

21. A

Equation must be balanced for charge and species. The equation must show the high energy electron.

[Link](#) to further reading on MS.

22. D

Only the charged (+) particles will be deflected onto the photographic plate.

[Link](#) to further reading on MS.

23. A.

The most polar molecule (methanol) will more strongly adsorbed to the polar stationary phase than the other molecules hence will have the longest retention time. The size area) of the peak for methanol is proportional to the concentration of methanol.

[Link](#) to further reading on HPLC. Disregard gas and thin layer chromatography when viewing this link just focus on HPLC.

24. B

$[\text{CHO}]^+$ = 29 m/z and is characteristic of an aldehyde. Option D also has an 29 m/z but it is not charged and hence will not appear on the spectrum.

[Link](#) to further reading on MS.

25. D

Using MS to detect purity

Options

Peaks at 45 m/z $[\text{CH}_3\text{COH}]^+$ and 15 m/z $[\text{CH}_3]^+$ are not characteristic of ethanol. As both molecules can produce fragments at 15 m/z. Peaks at 46 m/z is due to the parent ion of ethanol and 29 m/z represents the distinct $[\text{CH}_3\text{CH}_2]^+$ of ethanol.

[Lesson Solutions](#) further reading on using IR and MS to test for purity.

26. D

Mass Spectrometry (MS) involves ionization via high energy electrons.

Nuclear Magnetic Resonance (NMR) involves excitation of nuclear spins, which is a form of subatomic particle interaction.

Infrared Spectroscopy (IR) involves molecular covalent bond vibrations through absorption of infrared radiation.

Two summary sheet on the analytical techniques. Focus on MS, IR, ^1H NMR, ^{13}C NMR and HPLC.

[Summary](#)

[Summary](#)

27. A

28. B

This is all about balancing redox reactions in alkaline solutions.

[Lesson](#) [Solutions](#) further exercises on writing balanced redox half equations in acidic and alkaline solutions.

29. C

Step 1 find the total charge delivered.

$$\Rightarrow Q = I \times t = 0.0015 \text{ A} \times 30.0 \times 60 \times 60 = 162 \text{ C}$$

Step 2 find the total mol of electrons.

$$\Rightarrow 162 / 96500 = 1.68 \times 10^{-3} \text{ mol}$$

Step 3 find the mol of Cd



$$\Rightarrow \text{mol of Cd} = 1.68 \times 10^{-3} / 2 = 8.39 \times 10^{-4}$$

Step 4 find the mass of Cd

$$\Rightarrow 8.39 \times 10^{-4} \times 112.41 = 0.094 \text{ grams}$$

See further reading for question 2 on Faraday's Law.

30. D

Option A implies that a fuel cell can be recharged. Not true as no products are kept onboard to recharge.

Option B suggests that electrodes are used up in a fuel cell. This is not the case.

Option C is wrong as H^{+} ion travel to the cathode via the semipermeable membrane which is electrode B. Students should be aware that the fuel in a fuel cell always reacts at the anode.

Option D is correct.

[Link](#) to further reading on fuel cells.

[Lesson](#) [Solutions](#) (Fuel cells) [Video solutions](#)
[Summary of different types of fuel cells](#) [Solutions](#)

Section B

1. a)

58.8% C, 9.8 % H, 31.4%O.

convert to mass 58.8 g C, 9.8 g H, 31.4g O.

convert to mole $\frac{58.8 \text{ g C}}{12.0}$, $\frac{9.8 \text{ g H}}{1.0}$, $\frac{31.4 \text{ g O}}{16.0}$.

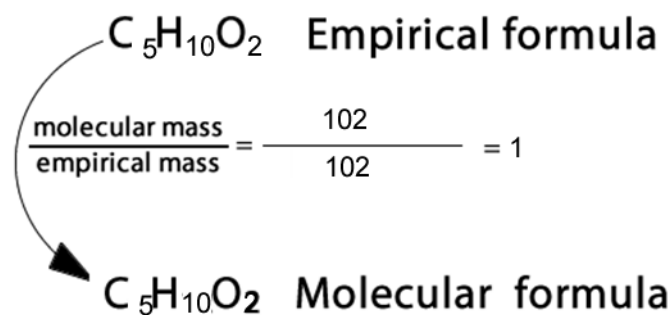
=> 4.9 9.8 2

Rounding up 5 10 2

=> $\text{C}_5\text{H}_{10}\text{O}_2$ Empirical formula

----- 1 mark for correct mol ratio ----- 1 mark for correct empirical formula

b.



----- 1 mark

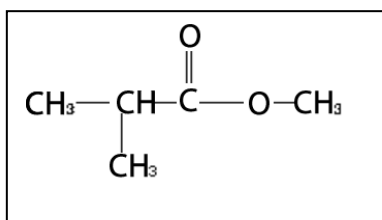
c) What information can be deduced from the trough in the IR spectrum at 1750 cm^{-1} ?

a C=O bond from the data book most likely a ketone. ---- 1 mark

d) What information can be deduced from the singlet at 3.7 ppm on the ^1H NMR

Most likely a CH_3 with no chemically unequivalent hydrogens on adjacent carbons to split the signal. ---- 1 mark

- e) Draw the structural formula of the compound given as the answer to question b) above.



----- 1 mark

- f) What are the names of two possible raw materials for the production of this compound?

i) *2-methylpropanoic acid* ----- 1 mark

ii) *methanol* ----- 1 mark

- g) What type of reaction forms this compound?

Condensation or esterification 1 mark

- h) What is the relevance of the signal peak at 0 ppm on the ^1H NMR spectrum?

It is the strong signal from 12 chemically equivalent hydrogens on tetramethylsilane used as a reference point for all other signals. ----- 1 mark

- i)

Compound	IR spectrum	^1H NMR	^{13}C NMR
$\text{CH}_3\text{CH}_2\text{COOCH}(\text{CH}_3)_2$	<i>Strong absorption at: 2850-3300 (due to C-H) 1670-1750 (due to C=O)</i>	<i>Four sets of peaks. A doublet representing the $(\text{CH}_3)_2$ A septet representing the CH A triplet representing the CH_3 A quartet representing the CH_2</i>	<i>Five peaks</i>
$(\text{CH}_3)_2\text{CHCOOCH}(\text{CH}_3)_2$	<i>Strong absorption at: 2850-3300 (due to C-H) 1670-1750 (due to C=O)</i>	<i>Four sets of peaks. Two doublets representing each of two $\text{C}(\text{CH}_3)_2$ groups Two septets representing the two CH next to the two $\text{C}(\text{CH}_3)_2$</i>	<i>Five peaks</i>

----- 2 marks for each correct row

Links to further reading on volumetric analysis and dilution

[Lesson](#)

[Solutions](#)

2. A chemistry student was tasked with determining the concentration of FeSO₄ in a liquid fertiliser.

A 20 mL aliquot was taken from the original bottle and placed in a 200mL volumetric flask and made to the mark with distilled water. Four 20 mL aliquots were then taken from the volumetric flask and placed in 4 separate conical flasks.

Each conical flask was titrated against a standard 0.0135 M KMnO₄ in an acidified solution. The titres achieved are given below.

21.10 mL, 19.24 mL, 19.14 mL, 19.18 mL

The balanced chemical equation for the reaction is given below.
 $\text{MnO}_4^- (\text{aq}) + 8\text{H}^+ (\text{aq}) + 5\text{Fe}^{2+} (\text{aq}) \rightarrow \text{Mn}^{2+} (\text{aq}) + 5\text{Fe}^{3+} (\text{aq}) + 4\text{H}_2\text{O} (\text{l})$

- a) Since no indicator was used in the titration, explain how the student would identify when the end point has been reached.

The deep purple colour of MnO₄⁻ would turn a persistent pale pink as it reduced to Mn²⁺. This is straight from the data booklet ----- 1 mark

- b) Calculate the average titre.

$$(19.24 + 19.14 + 19.18) / 3 = 19.19 \text{ mL}$$

- c) Calculate the amount, in mol, of MnO₄⁻ in an average titre.

$$\text{Mol of MnO}_4^- = C \times V = 0.0135 \text{ M} \times 0.01919 = 0.000259 \text{ mol} \quad \text{----- 1 mark}$$

- d) Calculate the concentration, in mol/L, of Fe in the original bottle of liquid fertiliser.

Step 1 calculate the mol of Fe in the 20ml aliquot

$$\Rightarrow 5 \times 0.000259 = 0.001295 \quad \text{---- 1 mark}$$

Step 2 calculate the mol of Fe in the volumetric flask

$$\Rightarrow (200 / 20) \times 0.001295 = 0.01295. \quad \text{---- 1 mark}$$

Step 3 calculate the concentration in mol/L in the original sample

$$\Rightarrow 0.01295 / 0.020 \text{ litres} = 0.65 \text{ M} \quad \text{---- 1 mark (correct sig figs and value)}$$

- e) Given the density of the liquid fertiliser is 1.10 g/mL give the concentration of Fe in %w/w.

Step 1 Convert 0.65 mol/litre into grams per litre

$$\Rightarrow 0.65 \times 55.8 = 36.13 \text{ g}$$

Step 2 convert 1000mL of fertiliser into mass of fertiliser

$$\Rightarrow 1.10 \text{ g/mL} \times 1000 \text{ mL} = 1100 \text{ grams} \quad \text{---- 1 mark}$$

Step 3 calculate %w/w

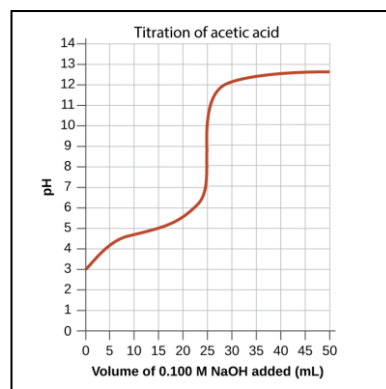
$$\Rightarrow (36.13 / 1100) \times 100 = 3.29\% \text{ w/w} \quad \text{---- 1 mark}$$

- f) Another student was tasked with determining the concentration of acetic acid in a commercial brand of vinegar using a standard 0.100 M NaOH solution.

- i. NaOH is not considered to be a primary standard. Explain why?
NaOH is hygroscopic (it absorbs water from the air), which makes it difficult to accurately weigh and obtain a pure sample. ---- 1 mark
- ii. Explain how a standard 0.100 M NaOH solution can be made when NaOH is not a primary standard?
By titrating the NaOH solution against a primary standard acid (such as potassium hydrogen phthalate, KHP), whose concentration is accurately known. This allows the concentration of NaOH to be determined precisely. ----- 1 mark.

- iii. The pH curve for the titration is given on the right. Select an appropriate indicator.

phenolphthalein, which changes colour (from clear to a persistent pink) around pH 8-9.



- iv. Give an approximate value for the equivalence point and justify your answer.

Just above pH 7 around pH 8. ----- 1 mark
This is because at the equivalence point all the acid has being converted acetate ion (CH_3COO^-) a weak base. ----- 1 mark

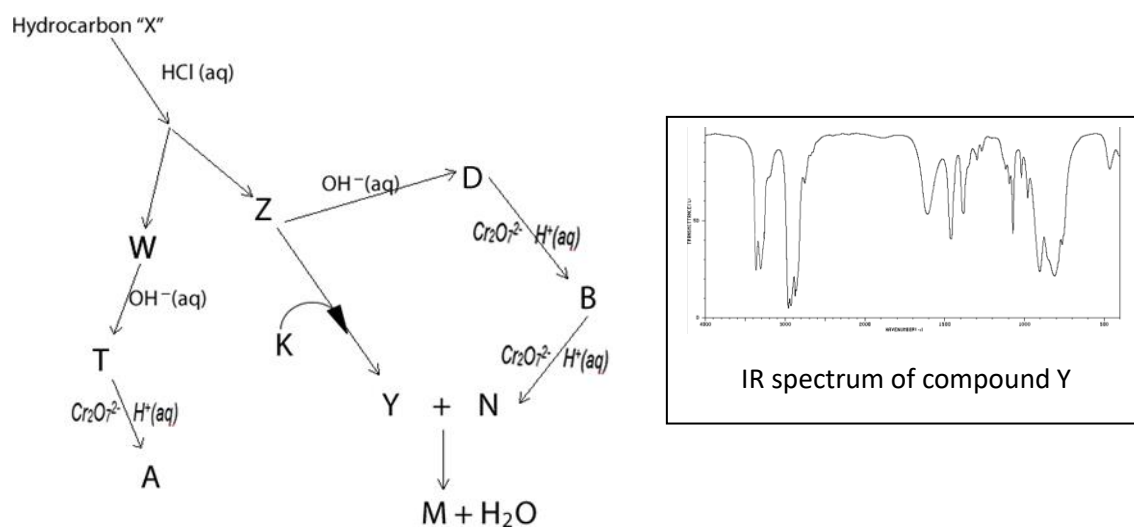
- v. The student consistently introduced parallax by reading the burette from the same incorrect position each time. Would this be classified as a human error (mistake), systematic or random error?

systematic error because the same incorrect reading technique was applied consistently, leading to a consistent deviation from the true value ----- 1 mark

- vi. How would this error impact the average titre achieved?

Since the parallax error is applied consistently in both readings the error would cancel out when taking the difference. Hence no impact. --- 1 mark

3. Consider the reaction pathway shown in figure 5 and the IR spectrum of compound Y



[Click](#) for a video on how to tackle the pathways question

Consider the information provided below when answering questions that relate to this pathway.

- The parent ion in the MS spectrum for D is at 60 m/z
- No reaction occurs when acidified $\text{Cr}_2\text{O}_7^{2-}$ is added to A.
- The IR spectrum for Y shows strong absorption at wavenumber 3300 -3500
- The high resolution ^1H NMR for W contains only a septet and a doublet whose areas are in the ratio 1:6 respectively.
- A brown Br_2 solution turns clear when added drop by drop to X.

a) Give the name for the hydrocarbon X.

_____ *propene* _____

1 mark

b) What type of reaction

i) formed Z _____ *addition* _____

ii) formed T _____ *substitution* _____

iii) formed N _____ *oxidation* _____

iv) formed M _____ *condensation* _____

4 marks

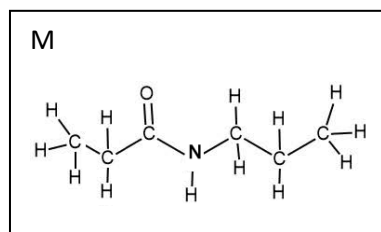
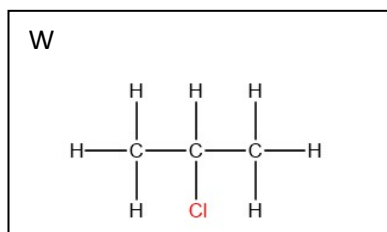
c) Identify reactant K and justify your answer

NH_3 ----- 1 mark

The IR spectrum of Y shows the presence of an N-H bond at wavenumber 3300 -3500 as per data book. --- 1 mark

d) Draw the structural formula for W and M

2 marks

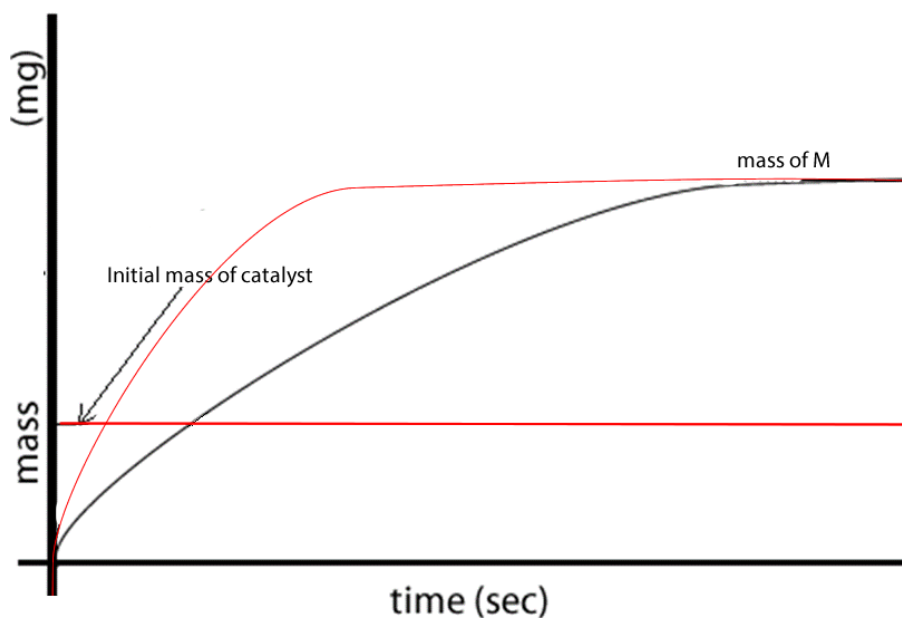


e) Give the IUPAC name for A and identify the class of compounds that it belongs to.

propanone (acetone) ----- 1 mark

Ketones ----- 1 mark

f) Below is a graph showing the mass of compound M formed over time in the absence of a catalyst. On the axes below draw the expected mass of M vs time graph **with** a suitable catalyst present, assuming no change in the conditions under which the current graph was drawn and give an explanation.



The catalyst increases the rate of the reaction but not the yield. ----- 1 mark

By providing an alternate reaction pathway with a lower activation energy. ---- 1 mark

g) On the same graph above draw how the mass of the catalyst changes over the course of the reaction.

4. Below is the chemical structure of the anticancer drug methotrexate (MTX) and dihydrofolate(DHF). Dihydrofolate is the natural substrate of the enzyme dihydrofolate reductase (DHFR). Dihydrofolate is converted to tetrahydrofolate (THF), which is necessary for DNA synthesis. This mechanism is particularly useful in cancer treatment, as it inhibits the rapid proliferation of cancer cells.

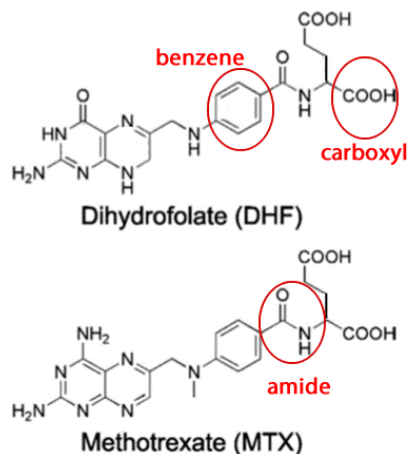


Figure 1

a) How many chiral centres are present in:

- methotrexate _____ 1 [Click](#) for further reading on chiral centres
- dihydrofolate? _____ 1 _____ ---- *1 mark if both correct*

b) Using the diagram in Figure 1, clearly name and circle three distinct functional groups present in MTX and DHF 2 marks

c) Given that DHF and MTX form very weak bonds with DHFR, suggest how methotrexate acts to reduce the production of tetrahydrofolate (THF) with reference to bonding and structure.

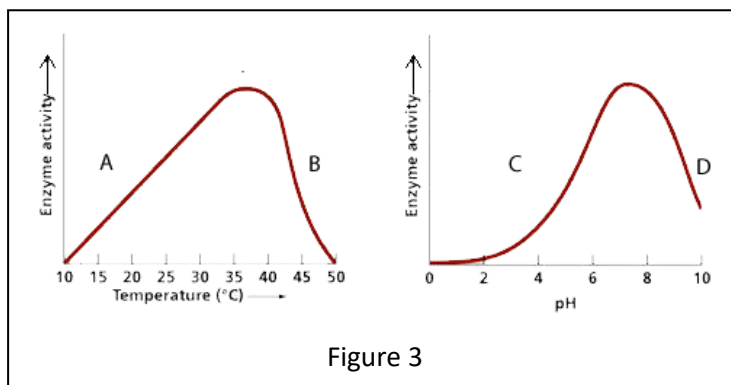
*MTX and DHF have a very similar structure and functional groups ----- 1 mark
 Both bind via relatively weak hydrogen bonds and dispersion forces to the active site. Hence MTX acts as competitive inhibitor by competing with DHF for the active site thus preventing the formation of THF ----- 1 mark*

d) Suggest how the effects of methotrexate can be overcome and explain why.

An increase in the concentration of DHF will cause it to outcompete MTX for the active site and hence reverse the inhibition.

[Click](#) for further reading on competitive enzyme inhibitors.

- e) Figure 3 shows the activity of dihydrofolate reductase at different temperatures and pH. Four regions are shown in the two graphs. Explain why the decline in activity is taking place in each region with reference to structure and bonding or available energy.



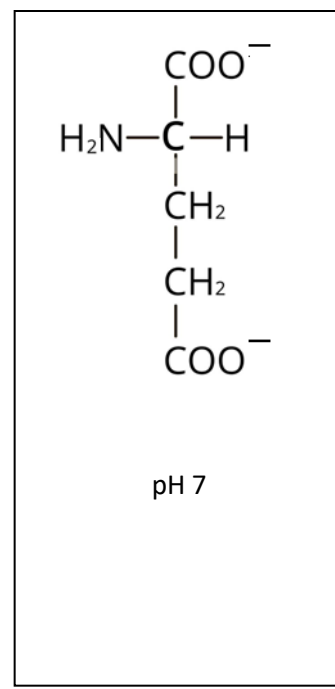
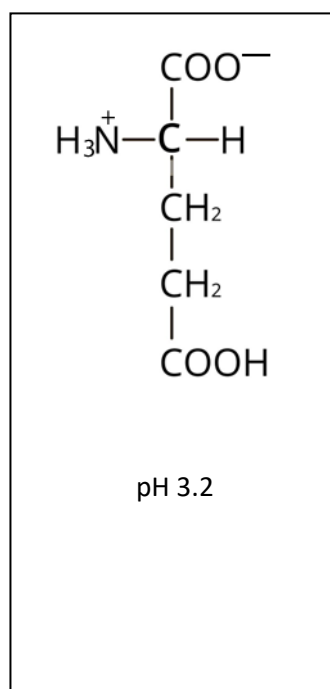
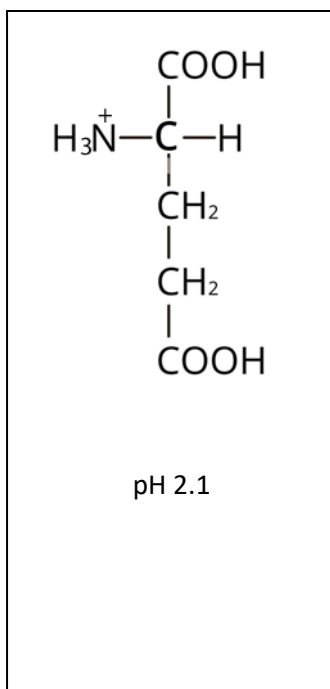
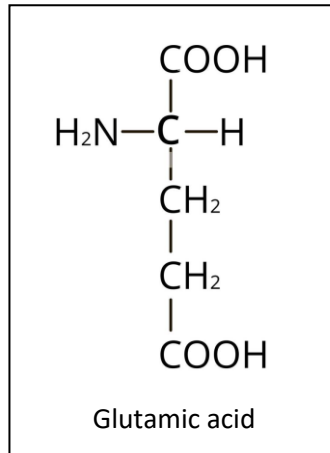
- i. **Region A** *Average kinetic energy of particles is very low for reactions to take place.*
- ii. **Region B** *increased heat energy disrupts relatively weak bonds, such as hydrogen bonds, dispersion forces, and dipole-dipole interactions, that maintain the tertiary and secondary structures of the enzyme. ----- 1 mark*
This disruption alters the shape of the enzyme's active site, preventing it from catalyzing the reaction effectively. ----- 1 mark
- iii. **Region C** *The COO^- groups on the amino acid side chains that form salt bridges will become protonated. ---- 1 mark*
The reduced attraction between neighboring COOH and NH_3^+ groups will lead to the uncoiling of the protein and disruption of the active site's shape. ---- 1 m
- iv. **Region** *The $-\text{NH}_3^+$ groups on the amino acid side chains that form salt bridges will become deprotonated to form $-\text{NH}_2$ ---- 1 mark*
The reduced attraction between neighboring COO^- and NH_2 groups will lead to the uncoiling of the protein and disruption of the active site's shape. ---- 1 mark

[Click](#) for further reading on enzymes

- f) The active site of Lysozyme found in the digestive tract has many glutamic acid residues. The isoelectric point of glutamic acid is 3.2, this is the pH at which glutamic acid exists as a zwitterion.

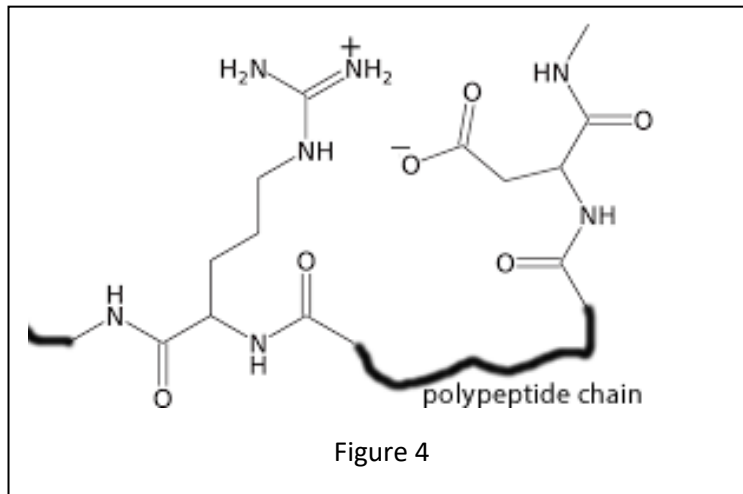
Draw the molecule at the pH shown in each box below.

3 marks



[Click](#) for further reading on zwitterions and protein structure

g) Consider the image of a polypeptide chain shown in fig. 4



i. What linear protein structure is represented by the segment labelled "polypeptide chain"?

_____ *Primary structure* _____ 1 mark

ii. Give the name of the type of bond formed between the two amino acid residues shown in the figure 4?

Salt bridge _____ 1 mark

iii. What structure of the protein contains the bond referred to in question ii, above?

_____ *tertiary or quaternary* _____ 1 mark

iv. Name the amino acids involved in the bond shown in figure 4.

Arginine + aspartic acid

2 marks

h) Consider the protein structure shown in figure 5.

i) What type of bonding forms structure A

h-bonding between neighbouring amide groups ----- 1 mark

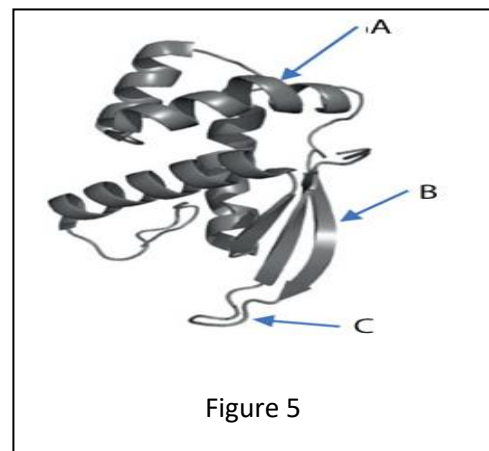
ii) What type of bonds form structure C

covalent (amide links) _____ 1 mark

iii) Name the structure labelled B

beta pleat. ----- 1 mark

[Click](#) for further reading on protein structure

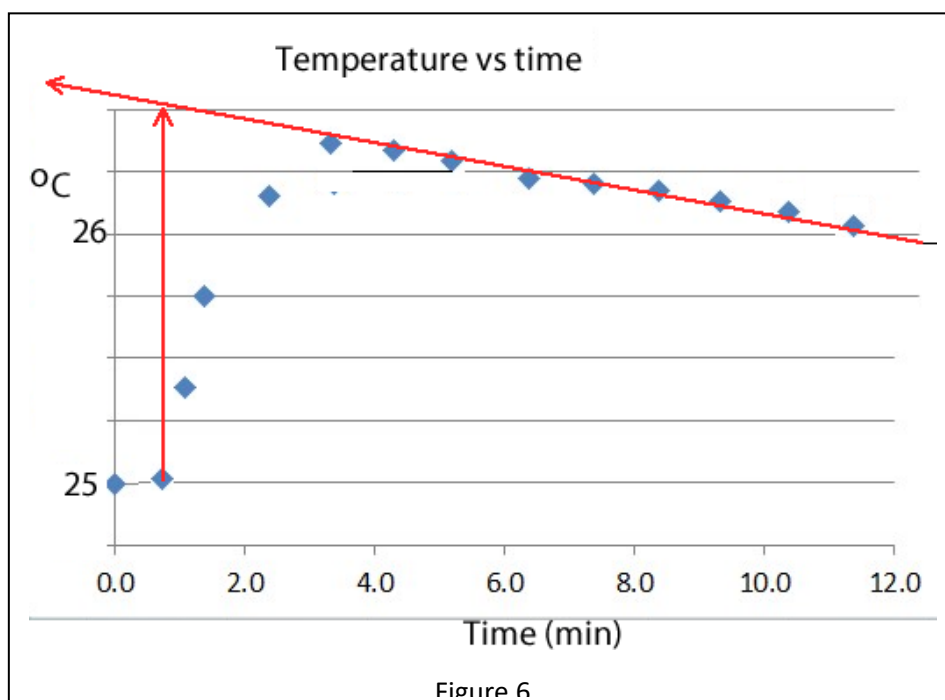
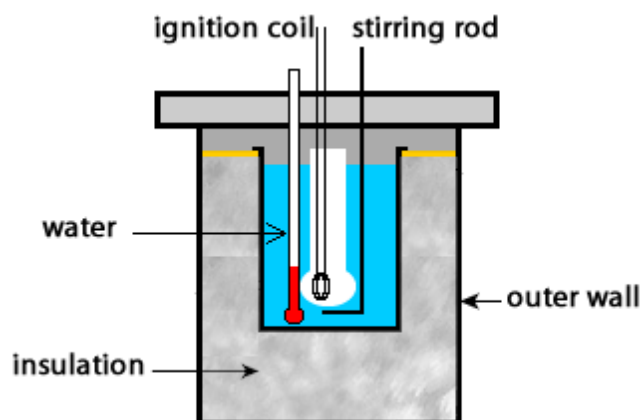


[Click](#) for further reading on calibrating calorimeters.

5. A bomb calorimeter, shown below, is used to determine, **experimentally**, the ΔH of the reaction below. 11.6 grams of butane are burnt in excess oxygen to raise the temperature of the water by $2.18\text{ }^{\circ}\text{C}$



The calorimeter was first calibrated by burning 6.840 g of liquid pentane in excess oxygen.
The change in temperature is read straight from the graph and is measured as $1.5\text{ }^{\circ}\text{C}$



- a) Given that the molar heat of combustion of pentane, at SLC, is 3509 kJ/mol calculate the calibration factor for this calorimeter. Give the answer to the right number of significant figures.

Step 1 Calculate the amount in mol of pentane

$$\Rightarrow 6.84 / 72.0 = 0.0950$$

Step 2 calculate the amount of energy released by 0.0950 mol of pentane

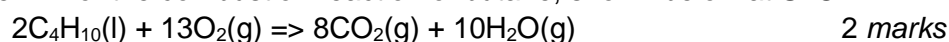
$$\Rightarrow 3509 \times 0.095 = 333.36 \text{ kJ} \quad \text{----- 1 mark}$$

*Step 3 calculate the calibration factor $333.36/1.5 = 2.2 \times 10^2 \text{ kJ/}^\circ\text{C}$ ----1 mark
(correct answer and sig figs)*

- b) Why must a calorimeter be calibrated before use?

Each calorimeter is different and loses heat to the environment at different rates. So we must calculate the relationship between energy and degree rise for each one.

- c) Calculate the ΔH for the combustion reaction of butane, shown below at SLC.



Step 1 calculate the mol of butane

$$\Rightarrow 11.6 / 58 = 0.20$$

Step 2 calculate the amount of energy released by 0.20 mol of butane.

$$\Rightarrow 222.24 \times 2.18 = 484.48 \quad \text{---- 1 mark}$$

Step 3 Calculate the molar heat of combustion of butane

$$\Rightarrow 484.48 / 0.20 = 2422.4 \text{ kJ/mol}$$

So for 2 mol, as the equation states, we would have $\Delta H = 4845 \text{ kJ/mol}$ ---- 1 mark

- d) Write the balanced thermochemical equation for the complete combustion of methane (CH_4) in oxygen gas (O_2) at 25°C , using average bond enthalpies. Show all calculations in the space provided below.

[Click](#) for further reading on bond enthalpies

Step 1 $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

Step 2: Identify the bonds broken and formed

Bonds Broken (Reactants):

In CH_4 , there are 4 X C-H $\Rightarrow 4 \times 414 = 1656$

In 2 O_2 , there are 2 X O=O $\Rightarrow 2 \times 498 = 996$

Total broken = 2652 ----- 1 mark

Bonds Formed (Products):

In CO_2 , there are 2 C=O $\Rightarrow 2 \times 804 = 1608$.

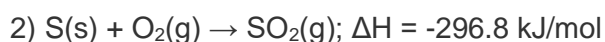
In 2 H_2O , there are 4 O-H $\Rightarrow 4 \times 463 = 1852$

Total formed = 3460 ----- 1 mark

$$\Delta H = 2652 - 3460 = 808 \text{ kJ}$$

$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \Delta H = -808 \text{ kJ/mol}$ ---- 1 mark

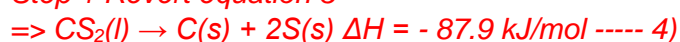
Bond enthalpies are found in the data booklet.



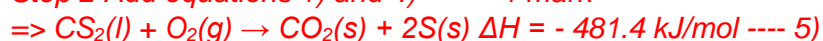
Given the thermochemical equations above, calculate the value of the ΔH for the reaction



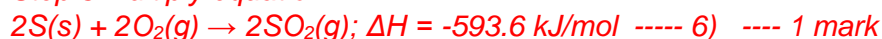
Step 1 Revert equation 3



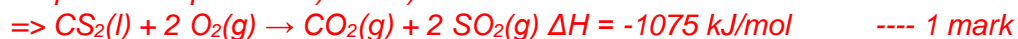
Step 2 Add equations 1) and 4) ----- 1 mark



Step 3 multiply equation 2 X 2

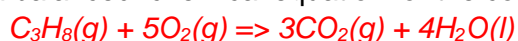


Step 3 Add equations 6) and 5)



f) A camper has 0.360 grams of propane left in his bottle and needs to boil 50.0 mL of water for tea.

i) Write a balanced chemical equation for the combustion of propane at SLC.



1 mark

ii) Assuming that the cooking utensil uses all the remaining propane and is 60% efficient in transferring heat energy into the water, calculate the maximum temperature that the 50.0 mL of water will reach if its initial temperature is 18.0 °C.

Step 1 Calculate the mol of propane

$\Rightarrow 0.360 / 44 = 0.00817$

Step 2 Calculate the amount of energy released from 0.00818 mol of propane

$\Rightarrow 0.00818 \text{ mol} \times 2220 \text{ kJ/mol} = 18.14 \text{ kJ}$ ----- 1 mark

Step 3 Calculate the amount of energy absorbed by the water

$\Rightarrow 18.14 \text{ kJ} \times 60\% = 10.88 \text{ kJ}$

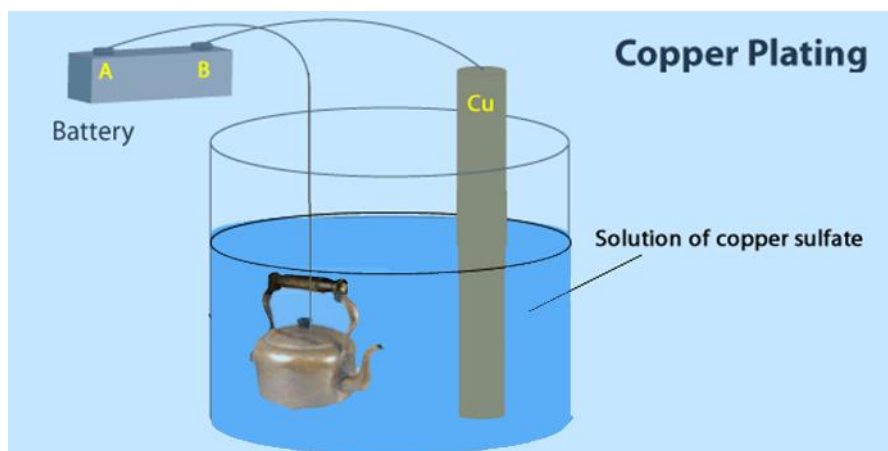
Step 4 Calculate the degree rise of 50 mL of water (density of water 1g/cm³)

\Rightarrow to raise 50 mL by 1 °C we require $50 \times 4.18 \text{ J} = 0.209 \text{ kJ}$

$\Rightarrow 10.88 / 0.209 = 52.1 \text{ °C}$

Final temperature $18.0 + 52.1 = 70.1 \text{ °C}$ ---- 1 mark

6. An iron kettle is to be copper plated using an electrolytic cell, as shown below. A total surface area of 55.8 cm^2 is to be copper plated to a depth of 2.00 mm . Density of copper metal is 8.933 g/cm^3 .



- a) Write the equation for the reaction occurring at the:
- i) anode _____ $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ _____
- ii) cathode _____ $\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu(s)}$ _____

2 marks

b) What is the polarity of terminal:

- i) A + ii) B -

1 mark

c) How long, in hours, should a current of 1.80 A flow.

Step 1 calculate the mass of copper to be plated on to the tea pot.

Mass = density X volume

$\Rightarrow \text{mass}_{\text{copper}} = 8.933 \times (55.8 \times 0.2) = 99.7\text{g}$ --- 1 mark

Step 2 calculate the mol of copper

$\Rightarrow n_{\text{Cu}} = 99.7 / 63.5 = 1.57 \text{ mol}$

Step 3 calculate the mol of electrons needed

For every mole of copper to be deposited we need 2 mol of electrons

$\Rightarrow n_{\text{electrons}} = 1.57 \times 2 = 3.14$

Step 4 calculate the charge of 3.14 mol of electrons ---- 1 mark

$\Rightarrow 3.14 \times 96500\text{Q} = 303010 \text{ Q}$

Step 5 calculate the time needed

$\Rightarrow Q = It$

$\Rightarrow Q/I = t$

$\Rightarrow 303010 / 1.80 = 168338 \text{ sec}$

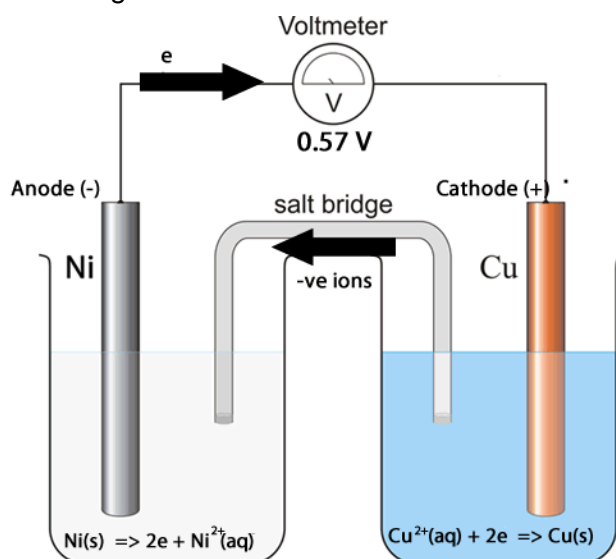
$\Rightarrow 46.8 \text{ hours}$ ---- 1 mark (correct sig figs)

d) What will happen to the concentration of Cu^{2+} ions in the solution? Explain why.

The concentration will remain relatively constant. ----- 1 mark

Copper metal is being oxidized into Cu^{2+} ions at the anode at the same rate as Cu^{2+} ions are being reduced at the cathode .

7. Consider the Cu/Ni galvanic cell shown below.



a) On the diagram above indicate the following

- direction of electron flow
- direction of negative ion movement
- the anode
- the cathode
- polarity of each electrode
- the EMF of the cell

3 marks

b) Give the half-cell equation occurring at the

i) anode

ii) cathode

2 marks

c) The copper half-cell contains 100.0 mL of a 0.100 M CuSO_4 solution. A small current of 2.02×10^{-3} A is produced and allowed to run for 48 hours. What is the concentration of the CuSO_4 solution, in mol per litre, after the 48 hour discharge?

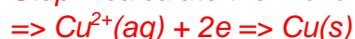
Step 1 Calculate the mole of electrons produced?

$$\Rightarrow Q = It$$

$$\Rightarrow Q = 0.00202 \times 48 \times 60 \times 60 = 349.1$$

$$\Rightarrow 349.1 / 96500 = 0.00362 \quad \text{----- 1 mark}$$

Step 2 calculate the mol of copper deposited



$$\Rightarrow 0.00362 / 2 = 0.00181 \text{ mol} \quad \text{----- 1 mark}$$

Step 3 calculate the mol of copper remaining in the 100 mL solution

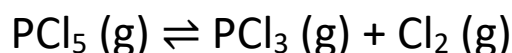
$$\Rightarrow \text{mol of copper remaining} = \text{mol initial} - \text{mol used}$$

$$\Rightarrow \text{mol of copper remaining} = 0.010 - 0.00181 = 0.00819$$

Step 4 calculate the concentration

$$\Rightarrow C = n/V \Rightarrow 0.00819 / 0.1 = 0.082 \text{ M} \quad \text{---- 1 mark}$$

8. At a given temperature a 3.44 g sample of phosphorus pentachloride (208.5 g mol⁻¹) is placed in a 2.34 litre vessel where it decomposes according to the equation below.



The decomposition reaction is allowed to come to equilibrium. It was found that the equilibrium mixture contained 1.03 grams of chlorine gas.

a) What percentage of the original PCl₅ decomposed?

Step 1 find the mole of PCl₅

$$\Rightarrow n = 3.44 / 208.5 = 0.0165 \quad \text{---- 1 mark}$$

step 2 find the mole of Cl₂

$$\Rightarrow n = 2.34 / 71.0 = 0.0145$$

Step 3 find the mol PCl₅ that reacted.

$$\Rightarrow n = 0.0145 \quad \text{---- 1 mark}$$

Step 3 find the percentage PCl₅ that reacted

$$\Rightarrow (0.0145/0.0165) \times 100 = 87.9\% \quad \text{---- 1 mark}$$

can also use an ICE table

Below is how you would do it with an ICE table

Set Up the ICE Table:

Species	Initial (mol)	Change (mol)	Equilibrium (mol)
PCl ₅	0.0165	-x	0.0165 - x
PCl ₃	0	+x	x
Cl ₂	0	+x	x

Note: In this case, x is the amount of PCl₅ that decomposes, which is equal to the moles of Cl₂ formed.

Find the Equilibrium Value of x Using Cl₂:

$$x = \text{Moles of Cl}_2 \text{ at equilibrium} = 0.0145 \text{ mol}$$

Calculate the Percentage Decomposed:

Percentage decomposed can be calculated using:

$$\text{Percentage decomposed} = \left(\frac{x}{\text{Initial moles of PCl}_5} \right) \times 100\%$$

$$\text{Percentage decomposed} = \left(\frac{0.0145 \text{ mol}}{0.0165 \text{ mol}} \right) \times 100\% \approx 87.9\%$$

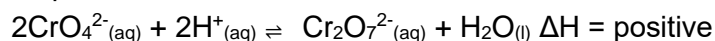
b) Calculate the value of the reaction quotient Q for this reaction, at equilibrium, given the temperature at which the reaction occurred. Units are not required.

$$\begin{aligned} & \frac{[\text{Cl}_2][\text{PCl}_3]}{[\text{PCl}_5]} \quad \leftarrow \text{---- 1 mark} \\ & = \frac{[0.00620]^2}{[0.000854]} \\ & = \frac{[0.00620]^2}{[0.000854]} \\ & = 0.045 \quad \leftarrow \text{---- 1 mark} \end{aligned}$$

- c) Consider the four equilibrium systems shown below. Predict the outcomes after the stated change by filling the table below. Circle the correct response.

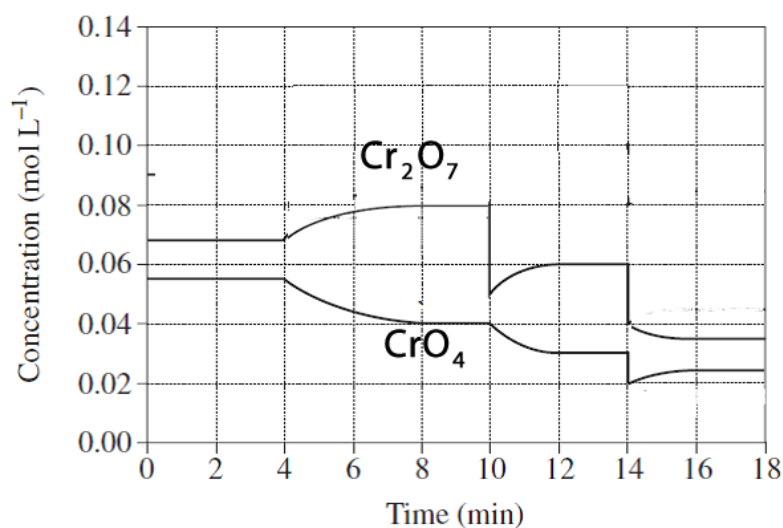
Reaction at equilibrium	Change	Equilibrium constant	Equilibrium position
$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g}) \Delta H_m = -\text{kJ mol}^{-1}$	Volume of the reaction vessel is halved	Increase Decrease Unchanged	Shifts to the left Shifts to the right No change
$\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g}) \Delta H_m = -\text{kJ mol}^{-1}$	Temperature is increased	Increase Decrease Unchanged	Shifts to the left Shifts to the right No change
$2\text{A}(\text{aq}) + \text{B}(\text{aq}) \rightleftharpoons \text{C}(\text{aq}) + 2\text{D}(\text{aq}) \Delta H_m = +\text{kJ mol}^{-1}$	Volume is doubled by the addition of distilled water	Increase Decrease Unchanged	Shifts to the left Shifts to the right No change
$2\text{G}(\text{aq}) + \text{H}(\text{aq}) \rightleftharpoons \text{E}(\text{aq}) + \text{D}(\text{aq}) \Delta H_m = +\text{kJ mol}^{-1}$	Volume is doubled by the addition of distilled water	Increase Decrease Unchanged	Shifts to the left Shifts to the right No change

- d) An acidified solution of chromate ions (CrO_4^{2-}) is allowed to come to equilibrium according to the equation shown below.



Chromate ions are yellow while dichromate ions appear red in solution.

The graph below shows the concentration of each species over time.



- i. What event could have happened at 4 minutes to shift the equilibrium as indicated in the graph?

Temperature increase

1 mark

- ii. Assuming the temperature of the solution remained unchanged what possible stress was applied to the system at 14 minutes?

Volume increase

1 mark

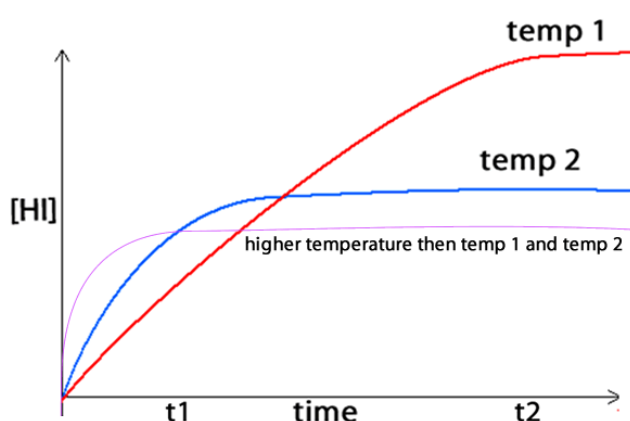
- iii. What event resulted in the equilibrium responding as shown at the 10 minute mark?

Cr₂O₇²⁻ was added

1 mark

- iv. At the 16 minute mark a catalyst was added. Describe how the equilibrium responds..

No change as it is already at equilibrium.



- e) Into a 2 litre sealed vessel was placed 2.0 mol of H₂ gas and 2.0 mol of I₂ gas and allowed to reach equilibrium. The graph of HI concentration is shown above at two different temperatures.

- i. Which temperature is the greatest? Give an explanation

Temperature 2 is the highest ----- 1 mark

It proceeds at a faster rate than temperature 1 ----- 1 mark

- ii. Decide whether the reaction is exothermic or endothermic and give a reason.

Exothermic ---- 1 mark

the rates are higher but the yield is lower at high temperatures for exothermic reaction ----- 1 mark

- iii. "At t₂ the forward reaction has stopped."

Is this comment true or false? False --- 1mark

Give a clear explanation as to why.

The system has reached a dynamic equilibrium meaning that the rate of the forward reaction is equal to the rate of the backward reaction and hence no net HI is formed. ----- 1 mark

- iv. On the set of axes shown above, draw the graph of [HI] at a temperature higher than both temp-1 and temp-2.

Secondary cells – have a finite amount of reactants onboard as the reactants are used up so does the current fall.

Fuel cell – have a constant supply of reactant and maintain a steady flow of current.

Secondary cells – produce products that adhere to the electrodes making it possible to reverse the reactions.

Fuel cells – constantly remove the product.

Secondary cells – operate at ambient or mild temperatures.

Fuel cells – can operate at temperatures around 800°C

f) A fuel cell can be made carbon neutral by using bioethanol.

i. What is meant by the term carbon neutral?

During the operation of the cell or the production, storage and transport of the fuel no net increase in atmospheric CO₂ takes place.

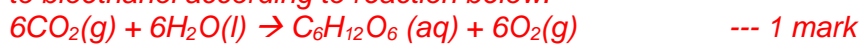
ii. Which Green Chemistry Principle is applied when using bioethanol.

The principle of "Use of renewable feedstocks" is applied when bioethanol is used.

iii. Justify your answer to question ii. above using two chemical equations, states included, of photosynthesis and anaerobic fermentation.

Photosynthesis:

During photosynthesis, plants absorb CO₂ to form glucose, which is a precursor to bioethanol according to reaction below.



Anaerobic fermentation:



During fermentation, glucose is converted to ethanol

Since bioethanol is derived from plant glucose, it is considered renewable because plants can be grown continuously, allowing CO₂ to be reabsorbed during photosynthesis. This ensures that the carbon emitted during fermentation is offset by the carbon absorbed during plant growth, making bioethanol a sustainable and renewable fuel source. ---- 1 mark

g) In a different fuel cell, bioethanol is used to generate electrical energy, and the carbon dioxide (CO₂) produced is recycled into greenhouses, where it is absorbed by plants. What should happen next for this to be an example of a circular economy?

For this to be part of a circular economy, the plants in the greenhouse should be harvested and used to produce bioethanol through fermentation. The bioethanol can then be used again in the fuel cell.

h) Cars capable of running on hydrogen fuel cells are been developed.

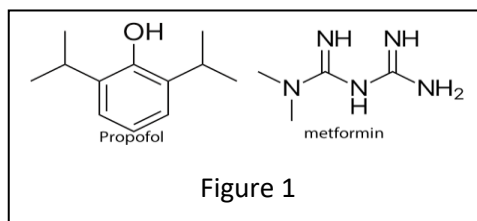
i. Discuss two advantages of hydrogen fuel over fossil fuel.

- *Renewable form different green energy sources*
- *Does not cause a net increase in atmospheric CO₂*

ii. Discuss two disadvantages of using hydrogen as a fuel source.

- *Infrastructure to store H₂ as a liquid is very expensive.*
- *Stored under high pressure makes it very dangerous*

10. Pictured in Figure 1 are two medicinal compounds: propofol, an intravenous anaesthetic, and metformin, an oral medication used to manage type-2 diabetes. Propofol is a liquid at room temperature with a boiling point of 256°C, while metformin is a solid, with a boiling point of 226°C. Ethyl ethanoate, the solvent, has a boiling point of 77°C. Propofol, being lipophilic, easily penetrates cell membranes, whereas metformin, being more hydrophilic, cannot.



A laboratory accidentally mixed these two compounds into one formulation, and they now need to be separated and purified due to their high cost. A senior chemist suggested using solvent extraction with **ethyl ethanoate** to purify the mixture.

- a) With reference to molecular structure and intermolecular bonding identify which compound will dissolve in ethyl ethanoate and explain why.

Propofol will dissolve in ethyl ethanoate, while metformin will not ---- 1 mark

Propofol is lipophilic due to its nonpolar alkyl chains and the presence of a lone hydroxyl group capable of weak hydrogen bonding but surrounded by non polar methyl groups. This makes it more soluble in nonpolar or slightly polar organic solvents like ethyl ethanoate, which can engage in van der Waals forces and weak dipole-dipole interactions with propofol. ---- 1 mark

Metformin, on the other hand, is highly hydrophilic due to its multiple amine groups and the ability to form strong hydrogen bonds with water, making it more likely to remain in an aqueous phase rather than dissolve in ethyl ethanoate.

- b) Given that propofol is unstable at high temperatures and may decompose if heated above 80°C, give a clear explanation as to why ethyl ethanoate is the solvent of choice and not water.

Using ethyl ethanoate allows for solvent evaporation without reaching a temperature that would degrade propofol. ---- 1 mark

Water, with a much higher boiling point of 100°C, would require higher temperatures for evaporation, potentially causing thermal decomposition of propofol, making it an unsuitable solvent in this context ---- 1 mark

- c) Outline a logical and sequential set of steps to separate and obtain pure propofol and metformin from the mixture as quickly as possible, ensuring no side reactions occur. Many ways that separation can be done. Filtration or via a separating funnel. Valid, logical and sequential steps received the marks.

Step 1 - Dissolve the mixture in ethyl ethanoate: Add the mixed formulation of propofol and metformin into ethyl ethanoate and stir to dissolve propofol. -- 1 mark

Step 2 - Liquid-liquid extraction: Add water to the mixture. Metformin, being hydrophilic, will dissolve in the aqueous phase, while propofol will remain in the ethyl ethanoate (organic) phase. ---- 1 mark

Step 3 - Use a separating funnel to carefully isolate the aqueous layer containing metformin and the organic layer containing propofol. ---- 1 mark

Step 4 - Purify metformin: Evaporate the water from the aqueous layer to recover pure metformin.

Purify propofol: Gently evaporate the ethyl ethanoate from the organic layer under reduced pressure to obtain pure propofol without risking decomposition. ---- 1 mark

Confirm purity is optional.

Or

Step 1 - Dissolve the mixture in a solvent that selectively dissolves propofol while leaving metformin as a solid. For example, use ethyl ethanoate, which dissolves propofol but leaves metformin undissolved. ---- 1 mark

Step 2 - Pour the mixture through a funnel lined with filter paper. The solid metformin will remain on the filter paper. The liquid filtrate, containing dissolved propofol in ethyl ethanoate, will pass through into the flask. – 1 mark

Step 3 - Dry the solid metformin collected on the filter paper to obtain the purified compound. --- 1 mark

Step 4 – Place the ethyl ethanoate-propofol mixture in an evaporating dish. Evaporate the ethyl ethanoate to recover the propofol via gentle heating. --- 1 mark

This method works when metformin remains solid and undissolved in the chosen solvent.

d) High-Performance Liquid Chromatography (HPLC) was put forward as an appropriate method for purifying a mixture of propofol and ethyl ethanoate using a **water-methanol** mobile phase.

- i. What type of stationary phase would you expect to find in the column? Explain how each component will interact with the stationary phase.

*The stationary phase in the column would likely be **non-polar**, ---- 1 mark
Propofol, being non-polar, will be adsorbed more strongly with the non-polar stationary phase through van der Waals forces, leading to longer retention times. Metformin, being more polar, will have weaker interactions with the stationary phase and will elute faster.
---- 1 mark*

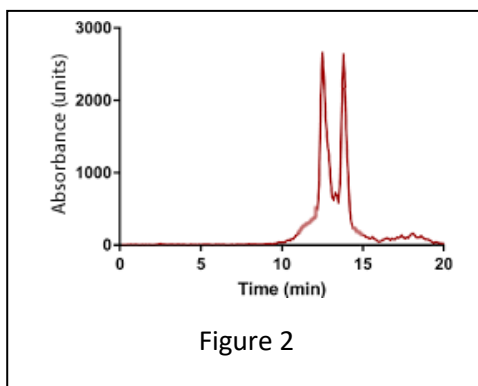
- ii. Describe how the retention time of each component of the mixture will be impacted if the temperature at which the column operates is increased. Explain why.

*Increasing the column temperature will decrease the retention time of both components. ---- 1 mark
This happens because higher temperatures reduce the viscosity of the mobile phase, which enhances the solubility and mobility of solutes, leading to faster elution times. ---- 1 mark
or
greater average kinetic energy of particles would most likely lead to weaker adsorbance to the stationary phase leading to faster retention times.*

- iii. Which compound is expected to elute first from the column? Explain why.

*Metformin will elute first ---- 1 mark
because it is more polar and will have weaker interactions with the non-polar stationary phase and stronger interactions with the polar mobile phase compared to propofol ---- 1 mark*

- e) The HPLC chromatogram produced by the mixture when run through the column is shown in figure 2. It contains overlapping peaks.



Without modifying the mobile or stationary phases, suggest two changes to the column conditions that will increase the separation of the peaks. Provide an explanation for each.

Any change that will keep the solvent in the column longer. For example

- *Reduced pressure used to push the solvent through the column. --- 1 mark*
This allows for greater interaction with the stationary phase leading to greater separation of peaks. --- 1 mark
- *Reduced temperature --- 1 mark*
This will increase the density of the solvent and slow the solvent down as it moves through the column.
- *Increase column length --- 1 mark*
greater interaction with the stationary phase. --- 1 mark

11. A student conducted an investigation to show that a brand of fertiliser, that stated it had 0% phosphate, did indeed have phosphate and was contaminating the local lake. She allowed farmers to use the fertiliser on a Monday and later measured the phosphate levels of the lake on Tuesday 9 am, Wednesday 4 pm, Thursday 1 pm, Friday 6 am and Saturday 7 pm. Each day she sampled a different location of the lake. The lake is also a source of drainage water from a local residential area where Saturday is a non-working day.

On each sampling day the student took a 150.0 mL sample of lake water from which she took three 20.0 mL samples and added excess 0.01M $\text{Ca}(\text{NO}_3)_2$ solution. She then filtered, washed and dried the $\text{Ca}_3(\text{PO}_4)_2$ precipitate before weighing it. Below are her results.

Day	Tuesday	Wednesday	Thursday	Friday	Saturday
Amount of PO_4^{3-} (ppm)	88	85	78	92	160

From her results the student concluded the fertiliser definitely contained phosphate which was washing into the lake.

- a) Give two reasons why her experimental technique will not enable her to reach a valid conclusion.

Any two valid reasons

Different sampling locations: The student collected samples from different locations in the lake each day. Phosphate levels can vary across the lake due to water flow, varying sources of contamination, and uneven distribution of pollutants. Without sampling the same location consistently, the data cannot accurately reflect the effects of the fertiliser. --- 1 mark Source of error and valid reason

Confounding variables from the residential area: The lake receives drainage water from a nearby residential area. Since Saturday is a non-working day and the highest phosphate level was measured on Saturday, this could indicate other sources of phosphate unrelated to the fertiliser (e.g., runoff from household detergents, sewage). The results are confounded by this additional phosphate input, and attributing it solely to the fertiliser is not justified. ---- 1 mark source of error and valid reason.

- b) Give three ways in which the investigation could be improved and the reason for the change.

Any suggestion that will improve the experiment with a valid reason was marked correct. Below are there examples

Change Reason

- | | |
|--|--|
| <i>1. Sample from the same location each day</i> | <i>This will provide a consistent set of data from a single point in the lake, allowing for more reliable tracking of changes in phosphate levels due to the fertiliser.</i> |
| <i>2. Measure phosphate levels before using the fertiliser</i> | <i>Establishing a baseline before the fertiliser is applied will show the pre-existing phosphate levels in the lake, which is necessary to determine any changes caused by the fertiliser.</i> |
| <i>3. Control for other sources of phosphate contamination</i> | <i>By monitoring phosphate input from the residential area and ensuring that its contribution is accounted for, the student can more accurately attribute any changes in phosphate levels to the fertiliser. This might involve sampling the drainage from the residential area and comparing it to lake levels.</i> |