Neap:

VCE CHEMISTRY UNITS 3&4

Neap's Nine Weeks of Deals: Week 8 giveaway

PRACTICE EXAM QUESTIONS

SOLUTIONS TO PRACTICE EXAM QUESTIONS

Practice exam questions

MULTIPLE-CHOICE QUESTIONS

Questions 1 and 2 refer to the following information.

The lead-based pigments used in traditional artists' paints can react with pollutants from the air to produce the black compound lead(II) sulfide, PbS. To restore the paintings to their original colour, the PbS is converted to colourless lead(II) sulfate, $PbSO_4$, by treating it with a solution of hydrogen peroxide. The reaction can be represented by the following equation.

$$PbS(s) + 4H_2O_2(aq) \rightarrow PbSO_4(s) + 4H_2O(l)$$

Question 1

In this reaction, the oxidation number of

A. lead changes from +1 to +2, and hydrogen peroxide acts as an oxidant.
B. sulfur changes from –2 to +6, and hydrogen peroxide acts as an oxidant.
C. lead changes from +2 to +4, and hydrogen peroxide acts as a reductant.
D. sulfur changes from –2 to +2, and hydrogen peroxide acts as a reductant.

Question 2

If 4.91 g of PbS is converted to $PbSO_4$ by 100.0 mL of a H_2O_2 solution, the concentration of the hydrogen peroxide solution is

A. 0.205 M
B. 0.821 M
C. 0.698 g L^{-1}
D. 6.98% m/v

Question 3

In an experiment, 4-hydroxybutanoic acid ($HOOC(CH_2)_3OH$) forms a polymer containing 500 monomer units.

The approximate molar mass (in g mol^{-1}) of this polymer is

A. 1.0×10^2
B. 6.8×10^3
C. 4.3×10^4
D. 5.2×10^4

Question 4

How many hydrogen atoms are there in one molecule of 3,3-dimethylhex-l-ene?

A. 14
B. 16
C. 18
D. 20

Question 5

If separate samples of pent-l-ene and pent-2-ene are reacted with bromine, the products will be

A. the same.

B. unsaturated compounds.

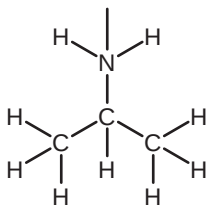
C. of lower mass than the organic reactant.

D. structural isomers of each other.

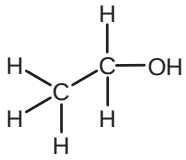
Question 6

Which of the following compounds would have a major peak in its mass spectrum at a mass/charge (*m*/*e*) ratio of 44?

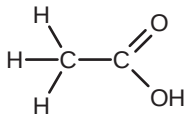
A.



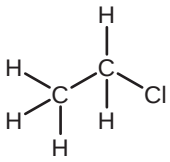
B.



C.

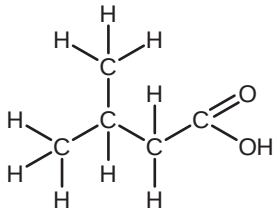


D.



Question 7

The systematic name for the compound shown below is



A. 3-methylbutanoic acid.

B. 2-methylbutanoic acid.

C. pentanoic acid.

D. 3,3-dimethylpropanoic acid.

Question 8

Which of the following statements regarding the preparation of glassware for a titration procedure is correct?

A. The pipette, burette and conical flasks should be rinsed with water only.

B. The pipette should be rinsed with water only, while the burette should be rinsed with water and then with the solution with which it will be filled.

C. After rinsing with water, the conical flasks must be thoroughly dried to remove all water.

D. Both the pipette and burette should be rinsed with water and then with the solution with which they will be filled.

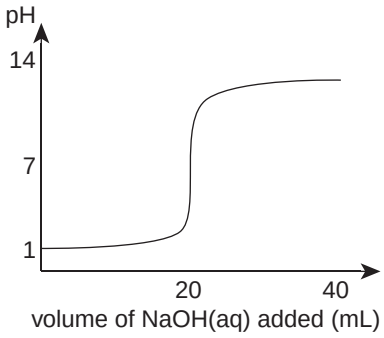
Questions 9 and 10 refer to the following information.

A titration is performed in which a 20.00 mL aliquot of 0.10 M hydrochloric acid solution is titrated with a 0.10 M solution of sodium hydroxide. The pH of the solution in the conical flask is monitored and recorded throughout the titration.

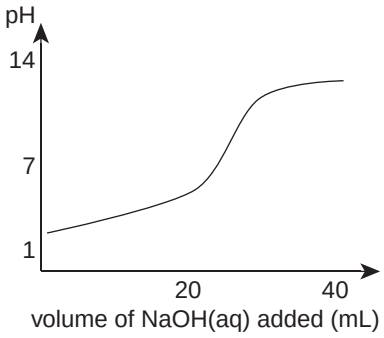
Question 9

Which of the following graphs shows the expected change in pH during the titration?

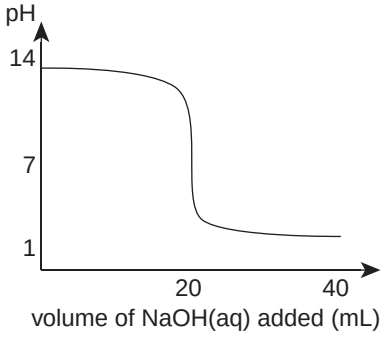
A.



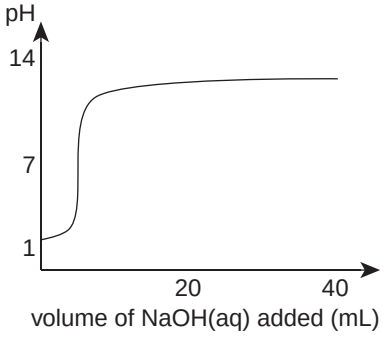
B.



C.



D.



Question 10

The experiment is repeated with 0.10 M ethanoic acid solution (CH_3COOH) instead of HCl.

In this case, the

A. equivalence point occurs when $n(CH_3COOH) = n(NaOH)$. The pH of the resulting solution is 7.

B. equivalence point occurs while $n(CH_3COOH)$ is less than $n(NaOH)$. The pH of the resulting solution is greater than 7.

C. equivalence point occurs while $n(CH_3COOH)$ is greater than $n(NaOH)$. The pH of the resulting solution is less than 7.

D. equivalence point occurs when $n(CH_3COOH) = n(NaOH)$. The pH of the resulting solution is greater than 7.

Question 11

What type of reaction is represented by the conversion of butan-l-ol to butanoic acid?

A. addition

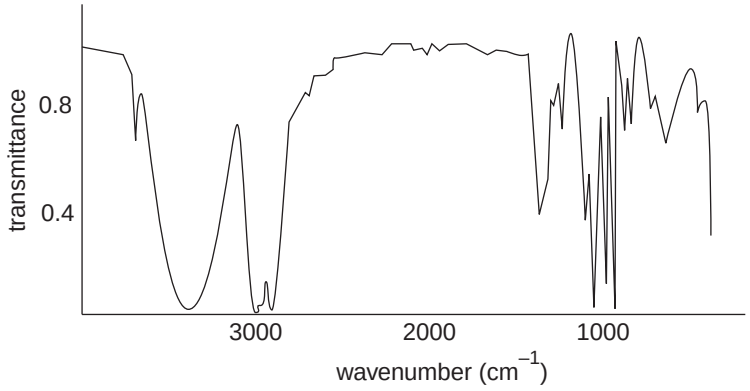
B. hydrolysis

C. oxidation

D. substitution

Question 12

The infrared spectrum of an organic compound is shown below.



The compound could be

A. propene.
B. 2-propanol.
C. propanoic acid.
D. propanone (CH_3COCH_3).

Question 13

What type of bonding links the amino acid monomers together to form a protein chain?

A. dispersion forces
B. hydrogen bonds
C. covalent bonds
D. ionic bonds

Question 14

Which of the following pairs of compounds are **not** isomers?

A. pentan-2-ol and 2,2-dimethylpropan-l-ol
B. butanoic acid and methyl propanoate
C. butane and cyclobutane
D. leucine and isoleucine

Question 15

A high-precision instrument maker suspects that the steel alloy that has been supplied contains less chromium and molybdenum than it should.

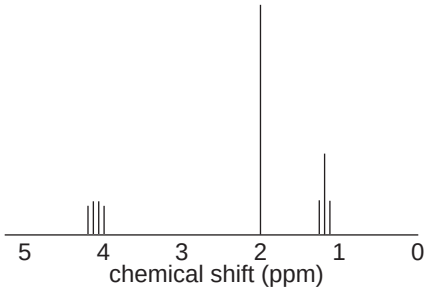
To determine the exact elemental composition of the alloy, the instrument maker should use

A. gravimetric analysis.
B. atomic absorption spectroscopy.
C. ^1H nuclear magnetic resonance spectroscopy.
D. high performance liquid chromatography.

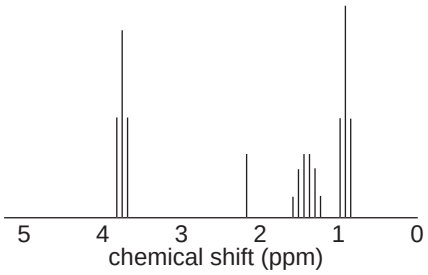
Question 16

Which of the following high resolution ^{1}H NMR spectra is that of 2-propanol?

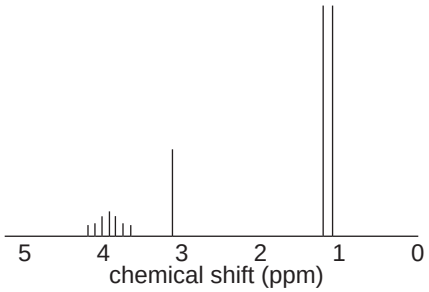
A.



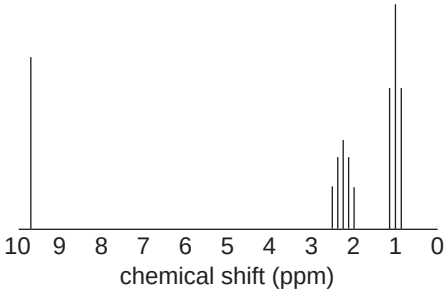
B.



C.

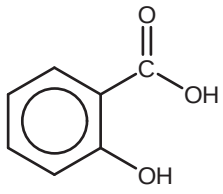


D.

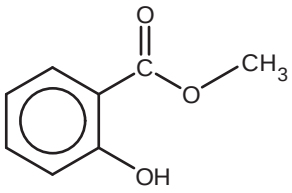


Question 17

The diagram below shows the structures of salicylic acid and methyl salicylate (oil of wintergreen).



salicylic acid



methyl salicylate

Which of the following statements regarding salicylic acid and methyl salicylate is **incorrect**?

A. The infrared spectra of both salicylic acid and methyl salicylate would include a strong band at approximately 1700 cm^{-1}.

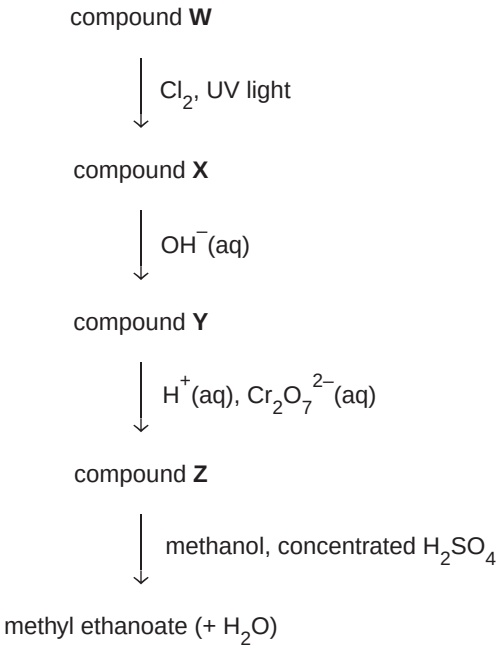
B. The hydrolysis of methyl salicylate would produce salicylic acid and methanol.

C. The ^{1}H NMR spectra of both salicylic acid and methyl salicylate would include four peaks at chemical shift values in the region 7 to 8 ppm.

D. Salicylic acid and methyl salicylate both contain the same percentage by mass of oxygen.

Question 18

The flowchart below represents a sequence of reactions that results in the formation of methyl ethanoate.



Which of the following correctly identifies the compounds labelled W to Z?

	W	**X**	**Y**	**Z**
A.	ethane	chloroethane	ethanol	ethanoic acid
B.	methane	chloromethane	methanol	methanoic acid
C.	ethene	chloroethane	ethanol	ethanoic acid
D.	ethene	chloroethene	ethanol	ethanoic acid

Question 19

A calorimeter is calibrated chemically by measuring the temperature change caused by the combustion of precisely 1.131 g of benzoic acid. The enthalpy of combustion of benzoic acid is given by the thermochemical equation below.

$$2C_6H_5COOH(s) + 15O_2(g) \rightarrow 14CO_2(g) + 6H_2O(l) \quad \Delta H = -6454 \text{ kJ mol}^{-1}$$

If the temperature increases by 30.94°C, the calibration factor of the calorimeter (in J $^oC^{-1}$) is

A. 208.5
B. 966.9
C. 1934
D. 3868

Question 20

Consider the following thermochemical equations.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393.5 \text{ kJ mol}^{-1}$$
$$S(s) + O_2(g) \rightarrow SO_2(g) \qquad \Delta H = -296.1 \text{ kJ mol}^{-1}$$
$$CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g) \qquad \Delta H = -1072 \text{ kJ mol}^{-1}$$

The enthalpy of reaction (in kJ mol^{-1}) for $C(s) + 2S(s) \rightarrow CS_2(l)$ is

A. –1762
B. –873.3
C. +86.3
D. +382.4

Question 21

Hydrogen sulfide (H_2S) is a weak, diprotic acid with ionisation constants $K_{a1} = 10^{-7}$ and $K_{a2} = 10^{-13}$. The following equilibria exist in a 0.10 M hydrogen sulfide solution.

$$H_2O(l) + H_2S(aq) \rightarrow H_3O^+(aq) + HS^-(aq)$$

$$H_2O(l) + HS^-(aq) \rightarrow H_3O^+(aq) + S^{2-}(aq)$$

Which species is present in the highest concentration in 0.10 M hydrogen sulfide solution?

A. $H_2S(aq)$
B. $H_3O^+(aq)$
C. $HS^-(aq)$
D. $S^{2-}(aq)$

Question 22

Sulfuryl chloride is formed when a mixture of sulfur dioxide and chlorine gas is heated according to the equation below.

$$SO_2(g) + Cl_2(g) \rightleftharpoons SO_2Cl_2(g) \quad \Delta H < 0$$

An appropriate procedure to increase the yield of SO_2Cl_2 would be to

A. increase the volume of the container.
B. increase the gas pressure by adding argon gas.
C. increase the temperature.
D. use an excess of SO_2 in the reaction mixture.

Question 23

Which of the following correctly states the energy changes occurring when chemical bonds are formed and broken?

A. Energy is released when bonds are formed and when they are broken.
B. Energy is absorbed when bonds are formed and when they are broken.
C. Energy is absorbed when bonds are formed and released when they are broken.
D. Energy is released when bonds are formed and absorbed when they are broken.

Question 24

Ammonium perchlorate (NH_4ClO_4) is used as the oxidising agent in solid fuel rocket boosters, as employed on the Discovery space shuttle. Its combustion generates temperatures in excess of 5800°C and lifts the space shuttle 45 km into the atmosphere in less than two minutes. An equation for this reaction is shown below.

$$3Al(s) + 3NH_4ClO_4(s) \rightarrow Al_2O_3(l) + 3NO(g) + 6H_2O(g) + AlCl_3(s) \quad \Delta H = -2667 \text{ kJ mol}^{-1}$$

The amount of energy (in MJ) generated by the combustion of 500 kg of ammonium perchlorate with excess aluminium powder is

A. 3.78
B. 3780
C. 1.13×10^4
D. 3.40×10^4

Question 25

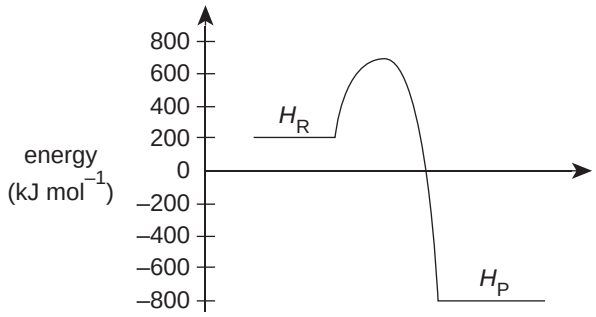
Which of the following shows acids arranged in order of increasing strength?

A. lactic acid < propanoic acid < hypochlorous acid
B. lactic acid < hypochlorous acid < propanoic acid
C. hypochlorous acid < propanoic acid < lactic acid
D. propanoic acid < lactic acid < hypochlorous acid

Questions 10 and 11 refer to the following information.

The diagram below represents the heat change for the reaction

$$2H_2S(g) + 3O_2(g) \rightarrow 2H_2O(l) + 2SO_2(g)$$



Question 26

The enthalpy of reaction (ΔH in kJ mol^{-1}) for the reaction $4H_2S(g) + 6O_2(g) \rightarrow 4H_2O(l) + 4SO_2(g)$ is

A. –2000
B. –1600
C. –1000
D. +600

Question 27

If a catalyst was used in this reaction, the activation energy (E_A in kJ mol^{-1}) for the reaction $2SO_2(g) + 2H_2O(l) \rightarrow 2H_2S(g) + 3O_2(g)$ could be

A. 500

B. 800

C. 1200

D. 1500

Question 28

An amount of energy *E* (in kJ) was added to a mass *m* (in g) of a substance of specific heat capacity *c* (in J g^{-1} K^{-1}).

The increase in temperature (in ºC) of the mass is given by the expression

A. $\frac{E}{m \times c} - 273$

B. $\frac{E}{m \times c}$

C. $\frac{1000E}{m \times c} - 273$

D. $\frac{1000E}{m \times c}$

Question 29

Passage of 0.10 faradays of electricity through an aqueous tin chloride solution deposited 5.94 g of tin at one electrode.

The oxidation number of tin in the chloride salt was likely to be

A. +1

B. +2

C. +3

D. +4

Question 30

80.0 mL of 0.150 M $Ba(OH)_2$ solution is added to 120 mL of 0.250 M HNO_3 solution.

The pH of the resulting mixture is closest to

A. 1.05

B. 1.13

C. 1.52

D. 12.5

Question 31

Consider the reaction shown in the equation below.

$$A + 2B \rightleftharpoons C \quad K = 0.318$$

Given that [A] = 0.532 M and [C] = 0.0914 M at equilibrium, the concentration of species B at equilibrium is

A. 0.234 M

B. 0.540 M

C. 0.735 M

D. 4.28 M

Questions 32 and 33 refer to the following information

The methylammonium ion ($CH_3NH_3^+$) is the weak acid conjugate of methanamine and reacts with water according to the equation below.

$$CH_3NH_3^+ + H_2O(l) \rightleftharpoons CH_3NH_2(aq) + H_3O^+(aq) \quad K_a = 2.7 \times 10^{-11} \text{ M}$$

Question 32

The pH of a 0.050 M solution of methylammonium is

A. 4.6

B. 5.9

C. 9.3

D. 12

Question 33

A small amount of 4 M hydrochloric acid is added to a solution of the methylammonium ion so as to increase the concentration of $H_3O^+(aq)$ ions.

After a period of time, when equilibrium is re-established,

A. the concentration of methylammonium ions will have decreased.

B. the pH will have increased.

C. the value of the fraction $\dfrac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]}$ will have increased.

D. the value of the fraction $\dfrac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]}$ will not have changed.

Question 34

In many industrial processes there is a conflict between the temperature required to achieve the maximum yield and the temperature desired to obtain the fastest rate of reaction. Consider the reactions below.

$$\text{I} \quad 2P(g) + 3Q(g) \rightleftharpoons 2R(g) \quad \Delta H > 0$$

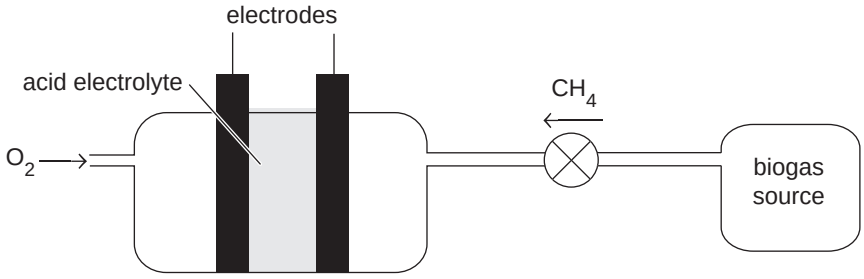
$$\text{II} \quad P(g) + 2Q(g) \rightleftharpoons 3R(g) \quad \Delta H < 0$$

For which of these reactions would this conflict arise?

A. I only
B. II only
C. both I and II
D. neither I nor II

Questions 35 and 36 refer to the following information.

The diagram below shows a laboratory model of a fuel cell designed to produce electricity using the methane found in biogas.



Question 35

The source of the methane in the biogas is the

A. anaerobic breakdown of organic matter by a variety of microorganisms.
B. aerobic breakdown of organic matter by a variety of microorganisms.
C. yeast-catalysed anaerobic breakdown of glucose.
D. yeast-catalysed aerobic breakdown of glucose.

Question 36

In this fuel cell, the reductant and the half equation for the reaction occurring at the cathode are

	Reductant	Cathode reaction
A.	oxygen	$CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e$
B.	methane	$CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e$
C.	oxygen	$O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$
D.	methane	$O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$

Question 37

When performing a gravimetric analysis experiment to determine the salt content of a dried soup sample a student obtained a result that was lower than expected.

A possible explanation for this incorrect result is that

A. the precipitate was not fully dried before weighing.
B. the precipitate was not washed prior to drying and weighing.
C. insufficient precipitating agent was added.
D. other ions were present in the soup sample that also reacted with the precipitating agent.

Question 38

The fatty acid, erucic acid, is found in a variety of plants, particularly in members of the *Brassica* family such as broccoli. It has the molecular formula $C_{22}H_{42}O_2$.

Based on its molecular formula it can be concluded that erucic acid is

A. a saturated fatty acid.
B. a monounsaturated fatty acid.
C. a polyunsaturated fatty acid.
D. an essential fatty acid.

Question 39

Glucocorticoid is a member of a class of compounds known as corticosteroids and is used in the treatment of itching, swelling and redness of the skin. It is a large and complex molecule of formula $C_{22}H_{29}FO_4$.

The analytical instrument **least** useful in determining the structure of glucocorticoid is the

A. infrared spectrometer.
B. ^1H nuclear magnetic resonance spectrometer.
C. mass spectrometer.
D. high performance liquid chromatograph.

Question 40

Which of the following organic compounds does not contain only five carbon atoms per molecule?

A. 2-methylpentan-3-ol
B. methyl butanoate
C. pentanoic acid
D. 2,2-dimethylpropanoic acid

SHORT ANSWER QUESTIONS

Question 1

Ethane reacts with chlorine gas at high temperatures and in the presence of UV radiation to produce $C_2H_4Cl_2$ along with other products.

a. State the type of reaction that has occurred to form this product.

_____

1 mark

b. What is the function of the UV radiation in this reaction?

_____

_____

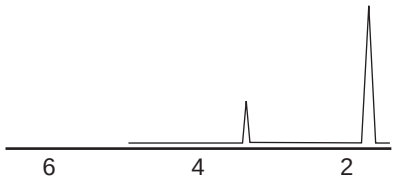
1 mark

c. $C_2H_4Cl_2$ can exist in two isomeric forms.

i. Complete the following table by drawing the structural formula and naming each isomer.

	Isomer I	**Isomer II**
structural formula		
systematic name		

ii. The low resolution ^1H NMR spectrum of one of the isomers of $C_2H_4Cl_2$ is shown below.



On the basis of this spectrum, which isomer (I or II as drawn in part **c.i.**) is present? Explain your answer.

_____

_____

_____

4 + 2 = 6 marks

d. The mass spectra of the two isomers would share a number of peaks at particular mass/charge (*m*/*e*) ratios, but would also include at least one peak from a fragment that would be only found in one of the isomers.

Draw the structural formula of a fragment that would be found in isomer I but not in isomer II.

1 mark
Total 9 marks

Question 2

A yeast extract is manufactured for use as a spread on sandwiches and as flavouring in stews. This extract has traditionally contained substantial quantities of salt. A student decides to determine the salt content of a yeast extract by performing a gravimetric analysis to calculate the chloride content. The following steps (**not** in correct order) are undertaken.

A *Collect the precipitate formed by passing it through filter paper in a Buchner funnel.*
B *Allow the precipitate to dry in an oven at 110ºC.*
C *Filter the solution to remove any insoluble impurities.*
D *Wash the precipitate to remove any adsorbed ions.*
E *Accurately weigh a sample of approximately 5 g of yeast extract and dissolve it in 50 mL of deionised water.*
F *Add excess silver nitrate solution to the filtrate to precipitate the chloride ions as AgCl(s).*
G *Weigh the precipitate to constant mass and record the results.*

a. Complete the following flowchart by placing the letters A to G in the boxes to indicate the order in which the steps should be undertaken.

☐ ⟶ ☐ ⟶ ☐ ⟶ ☐ ⟶ ☐ ⟶ ☐ ⟶ ☐

2 marks

b. The mass of yeast extract used by the student was 5.112 g. The silver chloride precipitate formed was weighed a number of times. The last five weighings shown below.

Weighing number	Mass (g)
1	1.183
2	1.137
3	1.109
4	1.110
5	1.108

i. Why were multiple weighings of the precipitate performed?

_____

ii. Calculate the average mass of silver chloride precipitate formed.

_____

iii. Calculate the mass of sodium chloride in the sample of yeast extract.

_____

_____

_____

iv. Determine the percentage mass (% m/m) of sodium chloride in yeast extract.

_____

_____

1 + 1 + 2 + 1 = 5 marks

c. Experimental error is associated with any gravimetric analysis.

State a source of error that could result in the calculated percentage mass of sodium chloride in yeast extract being

i. higher than the true value.

_____

_____

ii. lower than the true value.

_____

_____

1 + 1 = 2 marks
Total 9 marks

Question 3

Coconut oil is being investigated as a viable raw material in the production of biodiesel fuel. This has important economic implications for many small island nations of the Pacific Ocean, as petroleum-sourced fuels are prohibitively expensive. Approximately 50% of coconut oil is made up of lauric acid.

a. A sample of lauric acid is analysed and found to contain 72.0% carbon, 12.0% hydrogen and 16.0% oxygen by mass. A mass spectrum of the compound establishes that its relative molecular mass is 200.

i. Determine the empirical formula of lauric acid.

_____

_____

_____

_____

ii. Determine the molecular formula of lauric acid.

_____

_____

2 + 1 = 3 marks

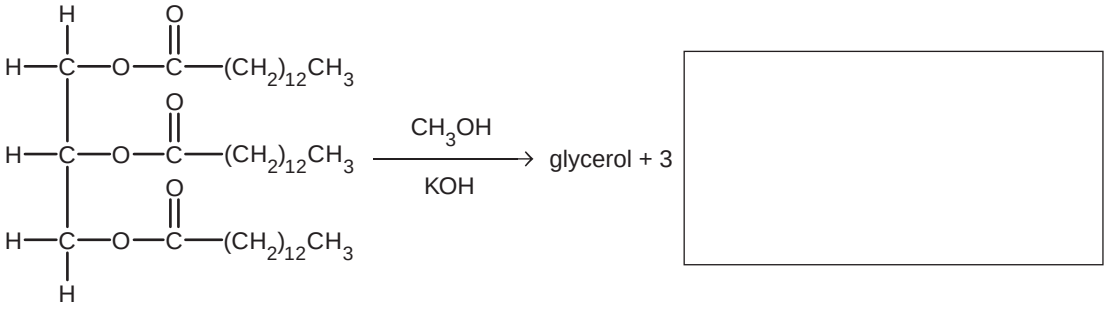
b. Is lauric acid saturated, monounsaturated or polyunsaturated?

_____

1 mark

c. Another important component of coconut oil is myristic acid, $CH_3(CH_2)_{12}COOH$, which forms a triglyceride named trimyristate. Trimyristate reacts with methanol in the presence of excess sodium hydroxide to form glycerol and large organic molecules that are the main components of biodiesel.

i. Complete the structural equation of the reaction below by drawing a formula for the organic molecule in the box provided.

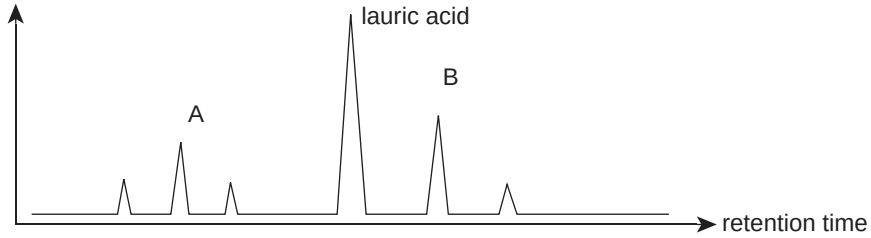


ii. Circle and name the functional group present in the organic molecule formed in the reaction above.

_____

1 + 1 = 2 marks

d. A small quantity of coconut oil is passed through a HPLC. A simplified chromatogram of the results is shown below.



Which peak (A or B) could be due to the myristic acid component of the coconut oil? Explain your answer.

_____

_____

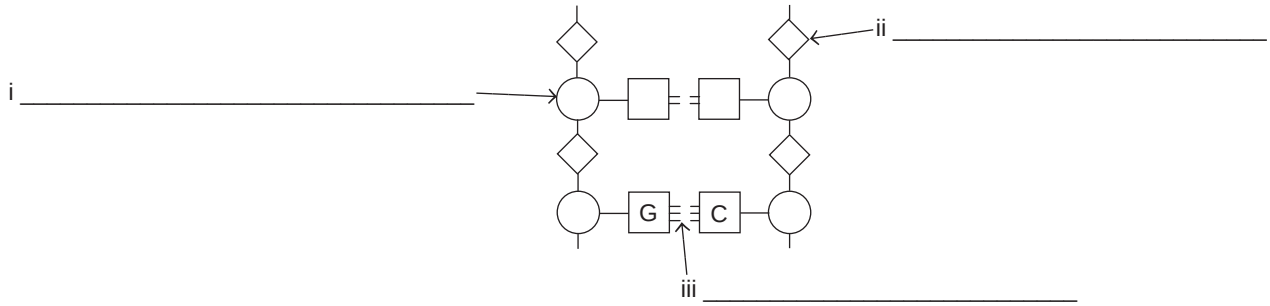
_____

_____

2 marks
Total 8 marks

Question 4

a. The diagram below shows a representation of a section of a DNA molecule.



Write appropriate labels for i, ii and iii.

1 + 1 + 1 = 3 marks

b. Name a functional group present in all four nitrogenous bases found in DNA.

_____

1 mark

c. Explain why

i. nucleic acids are acidic.

_____

_____

ii. the number of adenine molecules in a segment of double-stranded DNA can be used to determine the number of thymine molecules in the same segment.

_____

_____

_____

1 + 1 = 2 marks
Total 6 marks

Question 5

An organic compound with empirical formula $C_2H_3O_2$ was investigated in a series of experiments.

In **experiment 1**, 5.60 g of the compound was vaporised and found to occupy a volume of 1.64 L at a temperature of 150°C and a pressure of 765 mmHg.

In **experiment 2**, the infrared spectrum of the compound was obtained. The spectrum included a band at a wavenumber of approximately 1700 cm^{-1}.

In **experiment 3**, a 0.134 g sample of the compound was dissolved in water and titrated with a recently standardised 0.106 M NaOH solution. A titre of 21.43 mL was required to reach the endpoint of the titration.

a. Using the results from experiment 1,

i. determine the molar mass of the compound.

_____

_____

_____

_____

ii. determine the molecular formula of the compound.

_____

_____

2 + 1 = 3 marks

b. Does the information provided about experiment 2 allow you to state the functional group present in the compound? Explain.

_____

_____

_____

_____

2 marks

c. **i.** Using the results from experiment 3, calculate the mole ratio in which the compound and NaOH react.

_____

_____

_____

ii. What does this ratio allow you to conclude about the structure of the compound?

_____

3 + 1 = 4 marks

d. Draw a possible structural formula for the compound.

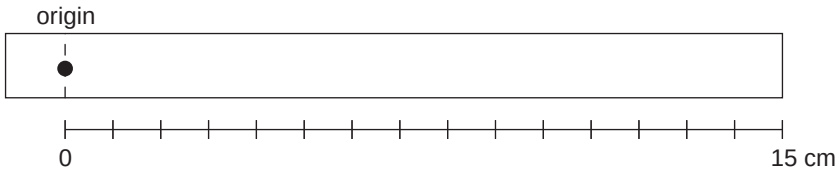
1 mark

Total 10 marks

Question 6

a. During a paper chromatography experiment, a dye sample was separated into two components. The R_f values of these components were 0.60 (green component) and 0.35 (yellow component).

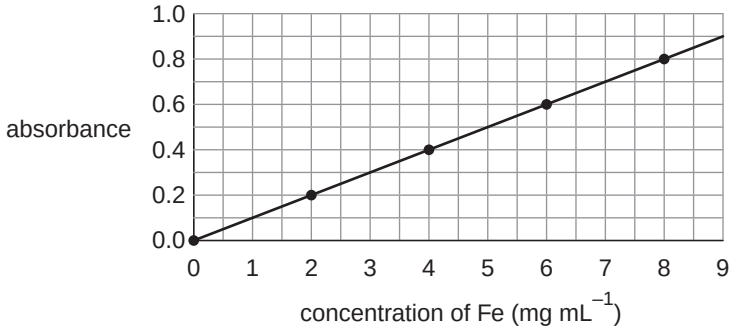
Sketch and label clearly the expected appearance of the chromatogram (to scale) when the solvent front had moved 12 cm from the origin.



2 marks

b. A student conducted an experiment using spectroscopy to determine the amount of iron in a sample of bore water. The iron was first combined with an organic compound, ferrozine, to form a purple complex.

Four standard solutions of iron were similarly treated with ferrozine, and their absorbances were determined in a spectrometer using an *appropriate wavelength* of light. The results are shown in the graph below.



A 6.0 mL sample of bore water was analysed using this method and its absorbance measured as 0.55.

i. Determine the concentration of iron in the bore water in mol L^{-1}.

_____

_____

_____

ii. How would an *appropriate wavelength* be determined for this analysis?

_____

_____

_____

2 + 2 = 4 marks
Total 6 marks

Question 7

When excess calcium carbonate pieces are added to dilute hydrochloric acid, a reaction occurs according to the equation shown below.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

a. Describe one way in which the rate of this reaction could be studied.

_____

_____

1 mark

b. On the axes provided below, sketch a graph to show the expected results of the rate investigation outlined in part **a**.

2 marks

c. How would the total volume of carbon dioxide gas produced in this reaction change (increase, decrease or remain the same) if a greater mass of calcium carbonate was used? Explain your choice.

_____

_____

_____

2 marks
Total 5 marks

Question 8

a. 2.00 mol of nitrosyl bromide ($NOBr_2$) is introduced into a 5.00 L evacuated vessel at a temperature of 350 K. The gas decomposes and reaches equilibrium according to the equation below.

$$2NOBr_2(g) \rightleftharpoons 2NO(g) + Br_2(g) \quad \Delta H < 0$$

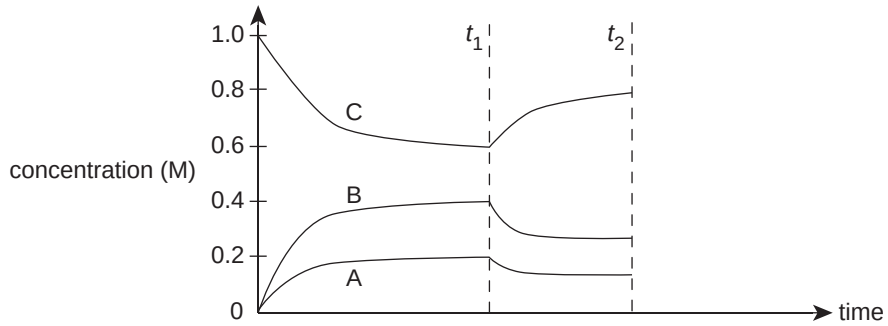
At equilibrium, 1.528 mol of $NOBr_2$ remained.

i. Calculate the concentrations of the three gases in the container once equilibrium had been established.

ii. Calculate the equilibrium constant for the reaction at this temperature.

2 + 1 = 3 marks

b. In a second experiment, a quantity of $NOBr_2$ was introduced into a vessel and allowed to reach equilibrium at constant temperature. A graph showing the changes in concentrations of the three gases over a period of time is shown below.



i. Identify gas B as shown on the graph above.

ii. At time t_1 the temperature in the reaction vessel was changed.

Was the temperature increased or decreased? Explain your answer in terms of Le Chatelier's Principle.

iii. At time t_2 a small quantity of chemical B was added while the temperature remained constant. On the same set of axes draw what changes would occur in the concentrations of gases A, B and C as the reaction proceeds to a new equilibrium position.

1 + 2 + 2 = 5 marks
Total 8 marks

Question 9

a. With the increasing need to find renewable energy sources, scientists have been investigating the use of chemicals in 'heat banks' rather than traditional brick or stone walls. A heat bank is a device that absorbs passive solar radiation and releases it into the home when the sun goes down, thus helping to keep a home cool during the day and warm at night. One such chemical is sodium sulfate decahydrate, $Na_2SO_4.10H_2O$, also known as Glauber's Salt. The chemical is placed into sealed sleeves and these are placed into the ceiling space of houses. When the temperature reaches 32ºC the salt dissolves in its own water of hydration and absorbs thermal energy according to the equation below.

$$Na_2SO_4.10H_2O(s) \rightleftharpoons Na_2SO_4(aq) \quad \Delta H = +78.2 \text{ kJ mol}^{-1}$$

i. Calculate the amount of heat energy that would be absorbed by 25.0 kg of Glauber's Salt as it changes from a solid to a solution at 32ºC.

_____

_____

_____

_____

ii. Determine the increase in temperature that would be experienced by 25.0 kg of water if it was to absorb the same amount of heat energy, given that the specific heat capacity of water is 4.18 J $ºC^{-1}$ g^{-1}.

_____

_____

2 + 1 = 3 marks

b. Solar energy is a promising renewable energy source. One method of capturing solar energy is through its use in producing biomass.

i. Write a balanced equation to represent the process by which green plants convert solar energy into the chemical energy in biomass.

_____

ii. The energy stored in biomass can be released by direct combustion.

State **one** disadvantage of this direct combustion of biomass as an energy source.

_____

_____

iii. Alternatively, the energy stored in biomass can be released through conversion of biomass to bioethanol.

State **one** way in which bioethanol may be used as an energy source

_____

1 + 1 + 1 = 3 marks

c. State **one** reason why nuclear fusion it is not widely used at present as an energy source.

_____

_____

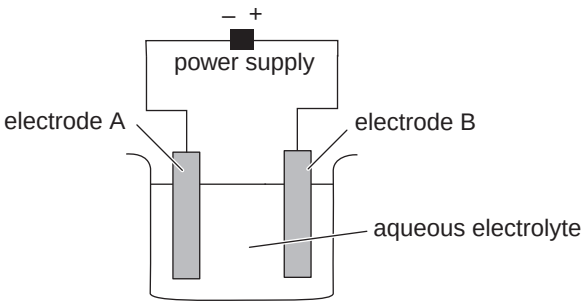
1 mark

Total 7 marks

Question 10

Three experiments were conducted to investigate electrolytic cell reactions.

a. In experiment 1, the apparatus shown below was used.



After current had passed through the cell for some time, a reddish brown liquid was formed at electrode B, while a metal was found deposited on electrode A.

i. Suggest the probable formula of the reddish brown liquid.

_____

ii. Explain why the deposited metal could not be magnesium.

_____

_____

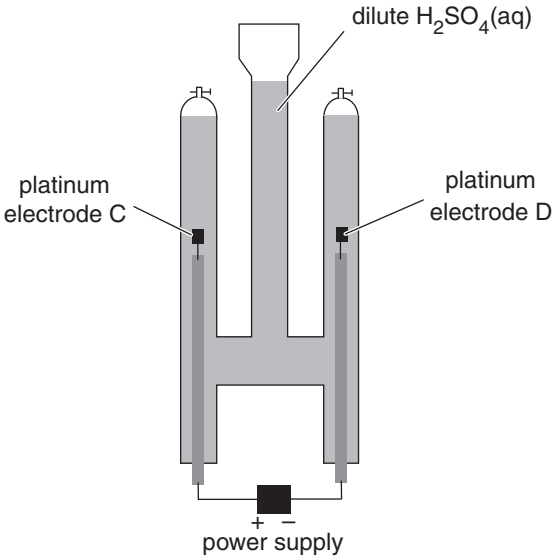
_____

iii. Suggest a possible electrolyte for this cell which is consistent with the observations made.

_____

1 + 2 + 1 = 4 marks

b. In experiment 2, the apparatus shown below was used with a dilute sulfuric acid solution as the electrolyte. A steady current of 0.060 amperes was maintained during the experiment.



i. Write a half equation for the gas-producing reaction expected at electrode C.

_____

ii. Determine the minimum amount of time needed to collect 25.0 mL of gas at electrode C, assuming standard laboratory conditions are used.

_____

_____

_____

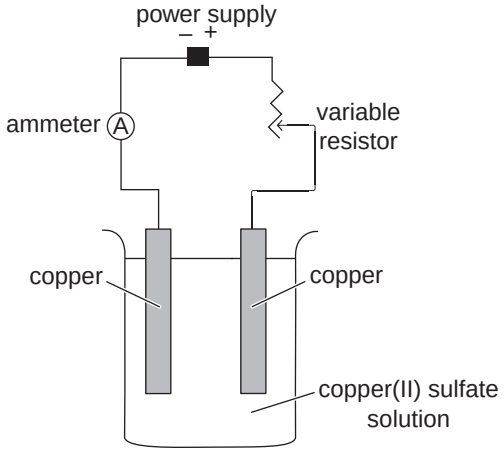
_____

_____

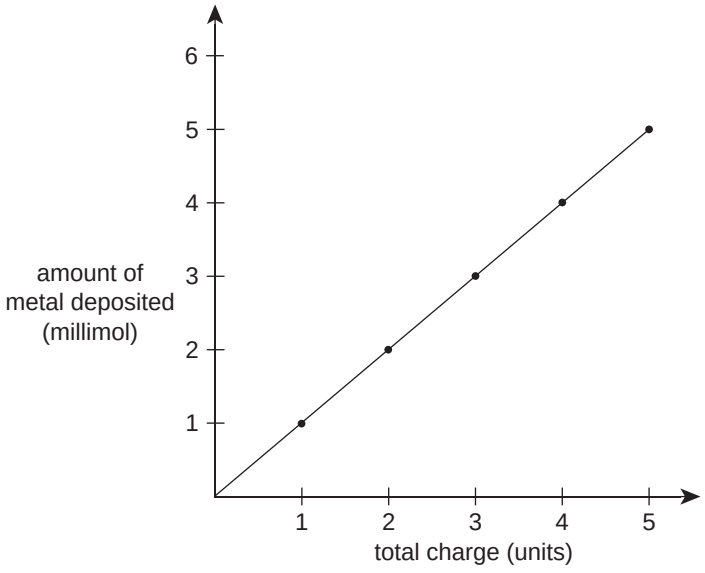
_____

1 + 3 = 4 marks

c. In experiment 3, the apparatus shown below was used with a dilute copper(II) sulfate solution as the electrolyte.



A measured current was passed through the cell for a fixed time, and the mass of copper deposited at one electrode was determined and recorded. The experiment was repeated several times to obtain the results shown in the graph below.



On the axes shown above, draw the results expected if the experiment was repeated using the same apparatus, but replacing the copper(II) sulfate electrolyte with a silver nitrate solution, and replacing the copper electrodes with silver electrodes.

2 marks

Total 10 marks

Solutions to Practice exam questions

Question 1 B

In PbS, the oxidation number (ON) of Pb is +2. The ON of S is –2.
In $PbSO_4$, ON(Pb) = +2, ON(S) = +6. The oxidation number of lead does not change (so **A** and **C** are incorrect). The change for the oxidation number of sulfur from –2 to +6 is an increase, so the PbS has been oxidised. The oxidant (causing this oxidation) is H_2O_2.

Question 2 B

$n(\text{PbS}) = \frac{m}{M} = \frac{4.91}{239.3}$ mol

$n(H_2O_2) = 4 \times n(\text{PbS}) = 4 \times \frac{4.91}{239.3} = 0.0821$ mol

$c(H_2O_2) = \frac{n}{V} = \frac{0.0821}{0.100} = 0.821$ M

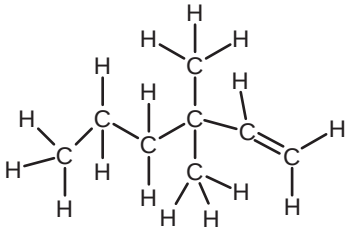
$c(H_2O_2) = \frac{m}{V} = \frac{n \times M}{V} = \frac{2.79}{0.100} = 27.9$ g L^{-1} or 2.79% m/v (hence **C** and **D** are incorrect)

Question 3 C

The polymer forms by condensation reactions between the hydroxyl (OH) and carboxyl (COOH) groups. When *n* monomers react, *n* – 1 molecules of water are produced.
Therefore $M(\text{polymer}) = 500 \times M(\text{monomer}) - 499 \times M(H_2O) = 500 \times 104 - 499 \times 18 = 4.3 \times 10^4$

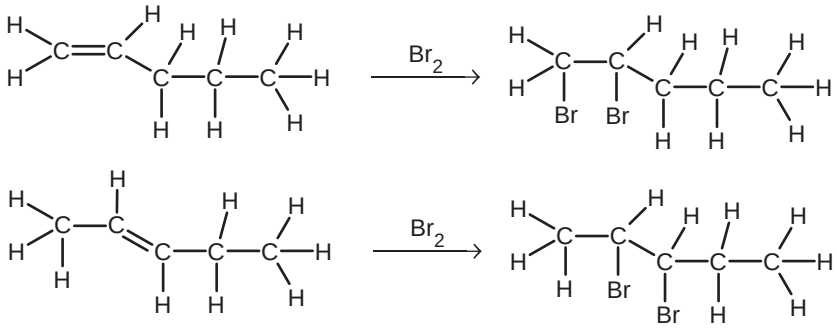
Question 4 B

Draw the molecule and count the hydrogen atoms. The molecule is an isomer of octene (C_8H_{16}).



Question 5 D

The relevant addition reactions are shown below.

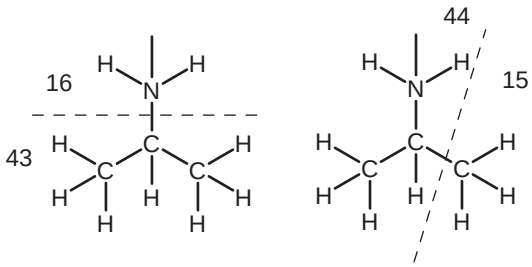


The products are 1,2-dibromopentane and 2,3-dibromopentane. These have the same molecular formula but different structural formulas. They are isomers, not the same compound (so **D** is correct, and **A** is incorrect). The products are saturated (so **B** is incorrect) and have a higher molar mass than the organic reactants (so **C** is incorrect).

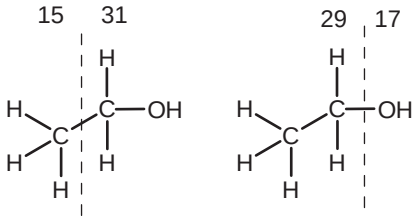
Question 6 A

Typical fragments are shown below.

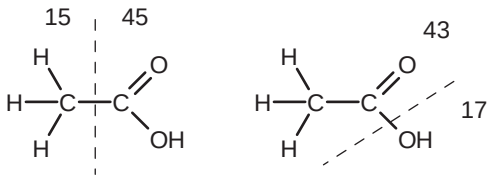
A.



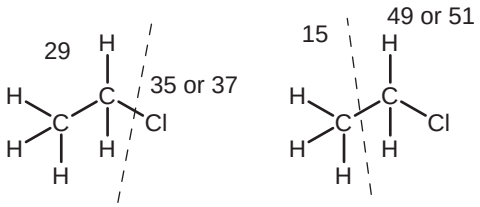
B.



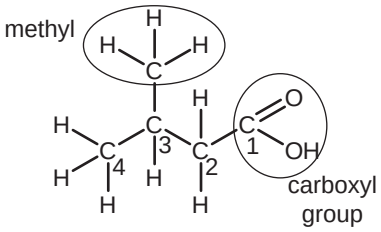
C.



D.



Question 7 A



The longest carbon chain has four carbons, giving the name butan (so answers **C** and **D** are incorrect). Numbering starts from the carboxylic acid carbon, so **A** (and not **B**) is the correct response.

Question 8 D

Pipettes and burettes are given a final rinse with the solution they are to contain. This ensures that no dilution of the solutions occurs. Conical flasks serve as reaction vessels only, and are not used to measure volumes of solutions. They are rinsed with water, and do not need to be dried before use.

Question 9 A

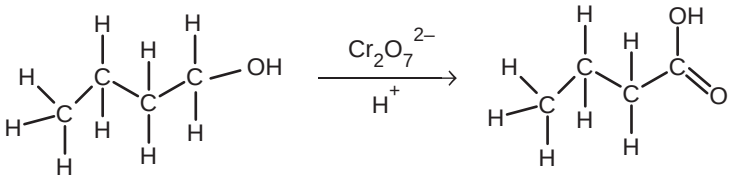
The relevant equation is $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$.
The pH of the flask contents is increasing as the base is being added to the acid (so **C** is not the required response). The equivalence point occurs when equal amounts (in mol) of the acid and base have been mixed. As both the acid and base are 0.10 M solutions, equivalence will occur when 20.00 mL of base has been added (so **D** is not the required response). For a strong acid/strong base titration, the pH changes rapidly at the equivalence point (so graph **A** is correct, and graph **B** is incorrect).

Question 10 D

The relevant equation is $CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$.
The equivalence point occurs when equal amounts (in mol) of the acid and base have been mixed. At this point the solution will contain the weak base ethanoate ion, CH_3COO^- (the conjugate base of the weak acid). The presence of this weak base makes the solution slightly alkaline, with a pH greater than 7.

Question 11 C

The relevant equation is



This conversion involves the addition of oxygen to the compound, and an increase in the oxidation number of the carbon atom (from –2 to –1). The conversion is therefore an oxidation.

Question 12 B

The broad band at 3300 cm^{-1} is typical of an OH (alcohol) group, as found in 2-propanol. Propene would show a peak in the range 1610 to 1680 cm^{-1} due to the C=C bond. Propanoic acid and propanone would show a peak around 1700 cm^{-1} due to the C=O bond.

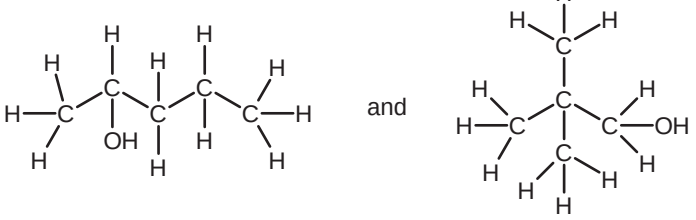
Question 13 C

Bonding between amino acids involves a peptide link, including a covalent bond between the carbon and nitrogen atoms. Bonding between side groups on non-adjacent amino acids may involve hydrogen and ionic bonds, and dispersion forces, but this is not bonding between monomers to form the protein chain.

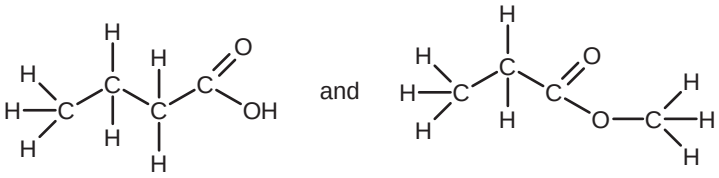
Question 14 C

Leucine and isoleucine are both amino acids with the same molecular formula. Drawing the other structures shows that the pair in **C** are the only pair where the two members do not have the same molecular formula, and are therefore not isomers.

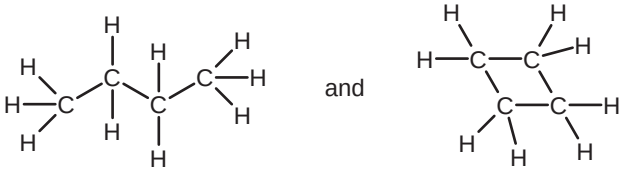
A.



B.



C.

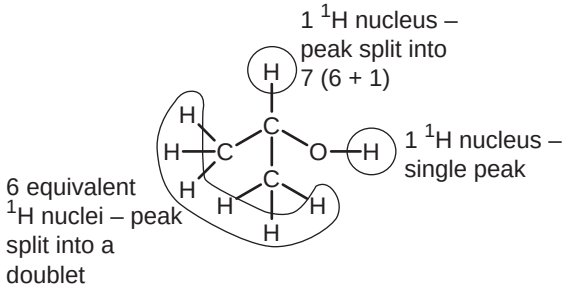


Question 15 B

For metal determination, AAS is used. HPLC and ^{1}H NMR are used to determine the composition and structures of organic compounds. Gravimetric analysis, while it could be used to determine metal concentration by precipitating the metal ion, is far less accurate than AAS and would not be suitable for high precision analysis.

Question 16 C

Draw the structure of 2-propanol and determine the number and types of ^{1}H nuclei present.

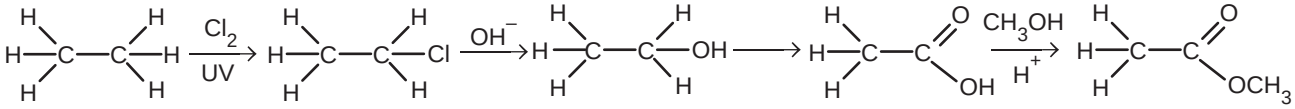


Question 17 D

Both molecules contain a carbonyl (C=O) group, and so both would include a strong band at approximately 1700 cm^{-1} on their infrared spectra (**A** is a correct statement and is therefore not the required response). The hydrolysis of the ester in methyl salicylate would produce salicylic acid and methanol (**B** is a correct statement and is therefore not the required response). The ^1H NMR spectra of both salicylic acid and methyl salicylate would include four peaks at chemical shift values in the region 7 to 8 ppm due to the four hydrogen atoms attached to the benzene ring in each molecule (**C** is a correct statement and is therefore not the required response). Salicylic acid and methyl salicylate have different molar masses and the same number of oxygen atoms per molecule. Their percentage by mass of oxygen could not therefore be the same (**D** is an incorrect statement and is therefore the required response).

Question 18 A

The relevant structures and names are shown below.



ethane chloroethane ethanol ethanoic acid methyl ethanoate

Question 19 B

$n(\text{benzoic acid}) = \frac{m}{M} = \frac{1.131}{122.0} = 9.270 \times 10^{-3}$ mol

2 mol of benzoic acid yields 6454 kJ

9.270×10^{-3} mol yields x

$x = \frac{6454 \times 9.270 \times 10^{-3}}{2} = 29.92$ kJ

$\text{CF} = \frac{29.92}{30.94} = 0.9669$ kJ $°C^{-1}$ = 966.9 J $°C^{-1}$

Question 20 C

To obtain the reaction required, add the first equation to twice the second.

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -393.5$ kJ mol^{-1}

$2S(s) + 2O_2(g) \rightarrow 2SO_2(g)$ $\Delta H = 2 \times -296.1$ kJ mol^{-1}

$C(s) + 2S(s) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$ $\Delta H = -985.7$ kJ mol^{-1}

To this equation, add the reverse of the third equation.

$CO_2(g) + 2SO_2(g) \rightarrow CS_2(l) + 3O_2(g)$ $\Delta H = +1072$ kJ mol^{-1}

$C(s) + 2S(s) \rightarrow CS_2(l)$ $\Delta H = +86.3$ kJ mol^{-1}

Question 21 A

H_2S is a weak acid and only partially ionises in water. With a K_a value of 10^{-7}, the equilibrium lies well to the left, i.e. very little H_2S is ionised. Even less HS^- is ionised, hence the species in highest concentration will be H_2S.

Question 22 D

To increase the yield of this exothermic reaction we need to push the position of equilibrium of the reaction further to the right and/or increase the equilibrium constant. A volume increase leads to a pressure decrease. This results in a shift to the left (more moles of gas) in order to increase the pressure. This decreases the yield (so **A** is incorrect). The use of an inert gas has no effect on the partial pressures of each reactant or product gas in the equilibrium system and so has no effect on the equilibrium position (so **B** is incorrect). An increase in temperature will favour the endothermic process and so the reaction will proceed backwards (so **C** is incorrect). An excess of the reactant gas SO_2 will force the reaction to the right to partly compensate (so **D** is correct).

Question 23 D

Bond breaking requires energy (so **A** and **C** are incorrect). Bond formation releases energy (so **B** and **C** are incorrect).

Question 24 B

$n(NH_4ClO_4) = \frac{m}{M} = \frac{500\ 000}{117.5} = 4.26 \times 10^3$ mol

3 mol of ammonium perchlorate yields 2667 kJ

4.26×10^3 mol yields x

$x = \frac{2667 \times 4.26 \times 10^3}{3} = 3.78 \times 10^6$ kJ = 3780 MJ

Question 25 C

The strongest acid is the one with the largest K_a value. This is lactic acid, with a K_a of 1.4×10^{-4}. The weakest acid is the one with the smallest K_a. This is hypochlorous acid, with a K_a of 2.9×10^{-8}.

Question 26 A

From the energy profile diagram, ΔH for the reaction = $H_P - H_R$ = –800 – 200 = –1000 kJ mol^{-1}. We require the change in enthalpy for double the reaction represented on the diagram, so ΔH = –2000 kJ mol^{-1}.

Question 27 C

The reaction for which we need to determine the activation energy is the reverse of the one represented in the energy profile diagram. As the activation energy is defined as the 'amount of energy required to initiate the reaction', E_A = 700 – (–800) = +1500 kJ mol^{-1}. As a catalyst is to be employed for the reaction, the activation energy must be less than 1500 kJ mol^{-1} (so **D** is incorrect) but still greater than 1000 kJ mol^{-1}, as this is the magnitude of ΔH for the reaction (so **A** and **B** are incorrect).

Question 28 D

$E = m \times c \times \Delta T$ (where E is in J)

$\Delta T = \frac{1000E}{m \times c}$ (as E was given in kJ)

Note that the ΔT *will be in K, since the units for the given* c *are J g^{-1} K^{-1}. However the change in temperature in K will be the same as the change in temperature in °C. The two scales have the same increments, but different zero points.*

Question 29 B

$n(\text{Sn}) = \frac{m}{M} = \frac{5.94}{118.7} = 0.050 \text{ mol}$

1 faraday is the charge on one mole of electrons, hence 0.10 faradays represents the charge on 0.10 mole of electrons.

$n(\text{Sn}) : n(\text{e}) = 0.050 : 0.10 = 1:2$

The charge on the Sn must therefore be +2.

Question 30 C

$n(Ba(OH)_2) = c \times V = 0.150 \times 0.0800 = 0.0120 \text{ mol}$

$n(OH^-) = 2 \times 0.0120 = 0.0240 \text{ mol}$

$n(HNO_3) = c \times V = 0.250 \times 0.120 = 0.0300 \text{ mol}$

$n(H^+) = 0.0300 \text{ mol}$

$n(H^+)$ in excess $= 0.0300 - 0.0240 = 0.00600 \text{ mol}$

$[H^+] = \frac{n}{V} = \frac{0.00600}{0.200} = 0.0300 \text{ M}$

$\text{pH} = -\log_{10}[H^+] = -\log(0.0300) = 1.52$

Question 31

$K = \frac{[C]}{[A][B]^2} = 0.318 \text{ M}^{-2}$

$[B] = \sqrt{\frac{[C]}{[A] \times 0.318}} = \sqrt{\frac{0.0914}{0.532 \times 0.318}} = 0.735 \text{ M}$

Question 32 B

$K_a = \frac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]} = 2.7 \times 10^{-11} \text{ M}$

$[CH_3NH_2] = [H_3O^+]$ at equilibrium and $[CH_3NH_3^+]_i \approx [CH_3NH_3^+]_{eq} = 0.050$ M (for a weak acid)

$\frac{[CH_3NH_2][H_3O^+]}{[CH_3NH_3^+]} = \frac{[H_3O^+]^2}{0.050} = 2.7 \times 10^{-11}$

$[H_3O^+] = 1.16 \times 10^{-6} \text{ M}, \therefore \text{pH} = 5.9$

Question 33 D

The addition of acid increases the concentration of H_3O^+ ions which, in turn, drives the reaction to the left. As the reaction only partly compensates for this change, the concentration of the H_3O^+ ions at the new position of equilibrium will still be higher than initially, and so the pH will be lower (so **B** is incorrect). As the reaction proceeds to the left, the concentration of $CH_3NH_3^+$ will increase (so **A** is incorrect). The ratio is equivalent to the K_a ratio and so will not change, as the reaction is in equilibrium.

Question 34 B

An increase in temperature will cause an increase in the rate of reaction, as the particles have more energy and so are more likely to overcome the activation energy barrier. An increase in temperature for an exothermic reaction will however lower the yield as the equilibrium moves to the left to try to decrease the temperature. The conflict thus arises only for exothermic reactions. For endothermic reactions, increasing temperature increases both the rate and yield of the reaction, thus no conflict arises.

Question 35 A

Biogas is produced by the anaerobic decomposition of organic matter by the action of a variety of microorganisms. It largely consists of a mixture of methane and carbon dioxide.

Question 36 D

The oxidation number of carbon in CH_4 is –4. The oxidation number of carbon in CO_2 is +4. Therefore oxidation has occurred and so the CH_4 is the reductant (so **A** and **C** are incorrect). Reduction occurs at the cathode (so **A** or **B** are incorrect).

Question 37 C

The errors listed in **A**, **B** and **D** all result in an over-estimation of the salt content. Insufficient precipitating agent results in less precipitate than expected, and so a lower calculated salt content.

Question 38 B

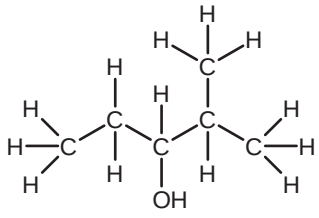
Rewriting the fatty acid formula as $C_{21}H_{41}COOH$ shows that it fits the general formula of a monounsaturated fatty acid, $C_nH_{2n-1}COOH$. The molecular formula does not provide information regarding the essential/non-essential nature of a fatty acid, hence **D** is not correct.

Question 39 D

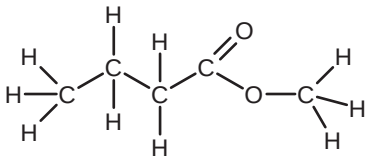
Infrared spectroscopy provides information about functional groups present in the molecule, so **A** is not the answer. ^{1}H NMR spectroscopy provides information about the arrangement of the hydrogen atoms within the molecule, so **B** is not the answer. The fragmentation pattern from the mass spectrometer provides structural information, so **C** is not the answer. HPLC is useful for the separation and identification of organic compounds, but not for the determination of the structure.

Question 40 A

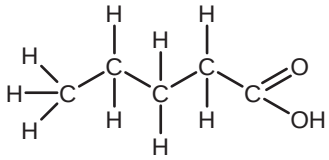
The relevant structures are shown below.



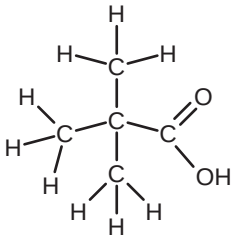
2-methylpentan-3-ol (6C)



methyl butanoate (5C)



pentanoic acid (5C)



2,2-dimethylpropanoic acid (5C)

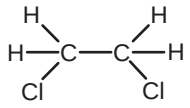
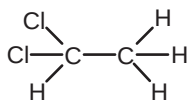
SHORT ANSWER QUESTIONS

Question 41

a. substitution 1 mark

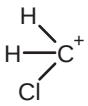
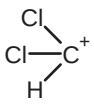
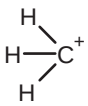
b. It is a catalyst. It provides the energy needed to break the Cl–Cl bond 1 mark

c. **i.**

	Isomer I	**Isomer II**
structural formula		
systematic name	1,2-dichloroethane	1,1-dichloroethane

4 marks
1 mark for each correct cell

ii. 1,1-dichloroethane 1 mark
Two peaks appear in the ratio 1:3, due to the single hydrogen nucleus on carbon 1, and the three hydrogen nuclei on carbon 2. 1 mark
(The spectrum of 1,2-dichloroethane would show only one peak.)

d.  or  or 

for 1,2-dichloroethane for 1,1-dichloroethane

1 mark
Total 9 marks

Question 42

a. 

2 marks

b. **i.** to ensure that the precipitate was dry 1 mark

ii. $\frac{1.109 + 1.110 + 1.108}{3} = 1.109$ g 1 mark

iii. $n(\text{AgCl}) = \frac{m}{M} = \frac{1.109}{143.4} = 7.734 \times 10^{-3}$ mol 1 mark

$n(\text{NaCl}) = n(\text{AgCl}) = 7.734 \times 10^{-3}$ mol

$m(\text{NaCl}) = n \times M = 7.734 \times 10^{-3} \times 58.5 = 0.4524$ g 1 mark

iv. $\%\text{NaCl} = \frac{m(\text{NaCl})}{m(\text{extract})} \times 100 = \frac{0.4524}{5.112} \times 100 = 8.850\%$ 1 mark

c. **i.** *Any one of:*

- Ions other than chloride contributed to the mass of the precipitate.
- The precipitate was still wet.
- any other suitable answer

1 mark

ii. *Any one of:*

- Some precipitate was lost during the filtration and transfer stages.
- Insufficient silver nitrate solution was added to precipitate all of the chloride ion.
- any other suitable answer

1 mark

Total 9 marks

Question 43

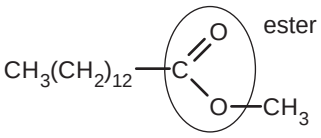
a. **i.** $n(C):n(H):n(O) = \frac{72.0}{12.0} : \frac{12.0}{1.0} : \frac{16.0}{16.0} = 6.0 : 12.0 : 1.0$

The empirical formula is $C_6H_{12}O$. 2 marks

ii. EFM = (6 × 12.0) + (12 × 1.0) + 16.0 = 100
RMM = 200 = 2 × 100
The molecular formula is $C_6H_{12}O \times 2 = C_{12}H_{24}O_2$. 1 mark

b. saturated *(the formula, $C_{11}H_{23}COOH$, fits the general formula of $C_nH_{2n+1}COOH$)* 1 mark

c.



2 marks
*1 mark for part **i***
*1 mark for part **ii***

d. B 1 mark
Myristic acid has the same carboxyl group (COOH) as lauric acid, but a larger molar mass. The larger mass leads to stronger dispersion forces between the molecule and the stationary phase, and hence a longer retention time. 1 mark

Total 8 marks

Question 44

a. **i.** deoxyribose sugar 1 mark

ii. phosphate ion 1 mark

iii. hydrogen bonds 1 mark

b. amine 1 mark

c. **i.** The OH group on the phosphate is able to donate a proton, and hence acts as an acid. 1 mark

ii. Adenine and thymine are a complementary base pair. This means that for each adenine molecule there will be a thymine molecule, and vice versa. Thus the numbers of the two bases must be equal in any section of double-stranded DNA. 1 mark

Total 6 marks

Question 45

a. **i.** $M = \frac{mRT}{pV} = \frac{5.60 \times 8.31 \times 423 \times 760}{765 \times 101.3 \times 1.64} = 118 \text{ g mol}^{-1}$ 2 marks

ii. EFM = (2 × 12.0) + (3 × 1.0) + (2 × 16.0) = 59
RMM = 118 = 2 × 59
The molecular formula is $(C_2H_3O_2) \times 2 = C_4H_6O_4$ 1 mark

b. The band at 1700 cm^{-1} is due to the carbonyl group (C=O). 1 mark
As this group is present in both esters and carboxylic acids (and other groups such as amides, aldehydes and ketones), we cannot be sure which functional group is present. 1 mark

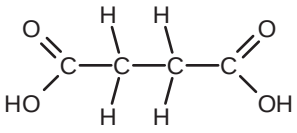
c. **i.** $n(C_4H_6O_4) = \frac{m}{M} = \frac{0.134}{118} = 1.136 \times 10^{-3}$ mol 1 mark

$n(NaOH) = c \times V = 0.106 \times 21.43 \times 10^{-3} = 2.272 \times 10^{-3}$ mol 1 mark

$n(C_4H_6O_4) : n(NaOH) = 1.136 : 2.272 = 1 : 2$ 1 mark

ii. The molecule contains two acidic protons. 1 mark

d.

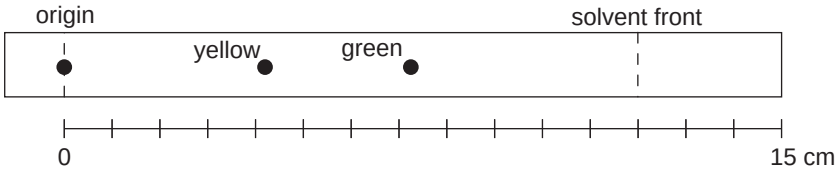


1 mark
Total 10 marks

Question 46

a. $R_f(y) = 0.35 = \frac{d(y)}{12}$, so $d(y) = 4.2$ cm

$R_f(g) = 0.60 = \frac{d(g)}{12}$, so $d(g) = 7.2$ cm 1 mark



1 mark

b. **i.** From the graph, [Fe] = 5.5 mg mL^{-1} (for absorbance 0.55) 1 mark

5.5 g $L^{-1} = \frac{5.5}{55.8}$ mol L^{-1} = 0.099 mol L^{-1} 1 mark

ii. A graph of absorbance versus wavelength for a solution of the iron/ferrozine complex would be obtained. 1 mark
The absorbance of maximum wavelength would be chosen (provided that no other component of the bore water sample absorbed this wavelength). 1 mark

Total 6 marks

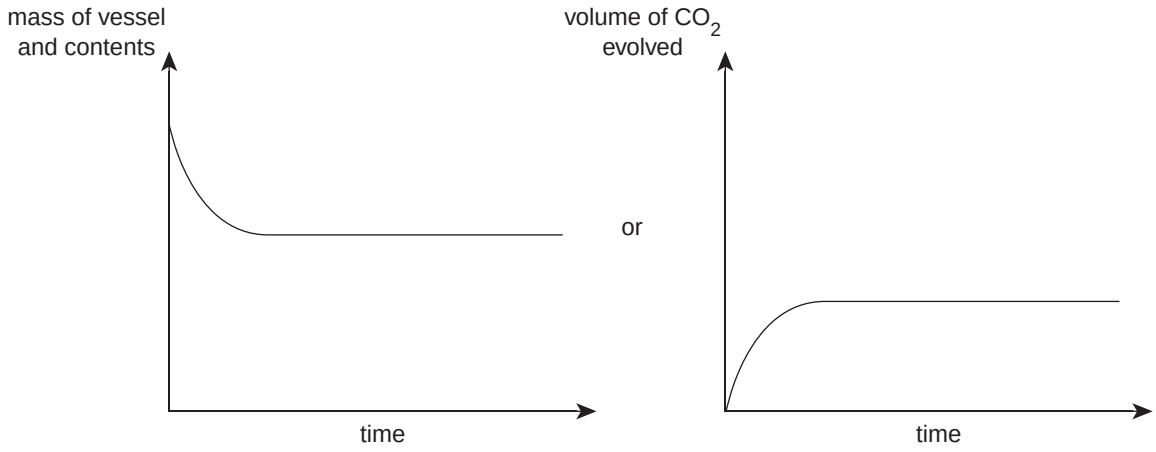
Question 47

a. *Any one of:*

- by recording the decreasing mass of the open vessel as the carbon dioxide escapes.
- by collecting and recording the volume of the carbon dioxide evolved over time.
- any other suitable method.

1 mark

b.



*Any graph consistent with the response given to part **a** is acceptable.*

2 marks
1 mark for correctly labelled axes
1 mark for correct shape of the graph

c. remains the same 1 mark

The calcium carbonate was in excess. Adding more of the excess reactant will not change the yield. 1 mark

Total 5 marks

Question 48

a. **i.**

	Reactants	**Products**	
Mole ratio in equation	$2NOBr_2$	2NO	Br_2
n_i	2.00	0	0
change	–0.472	+0.472	+0.236
n_{eq}	1.528	0.472	0.236
$[\ ]_{eq}$, V = 5.00 L	0.306	0.0944	0.0472

$[NOBr_2]$ = 0.306 M, [NO] = 0.0944 M, $[Br_2]$ = 0.0472 M 2 marks

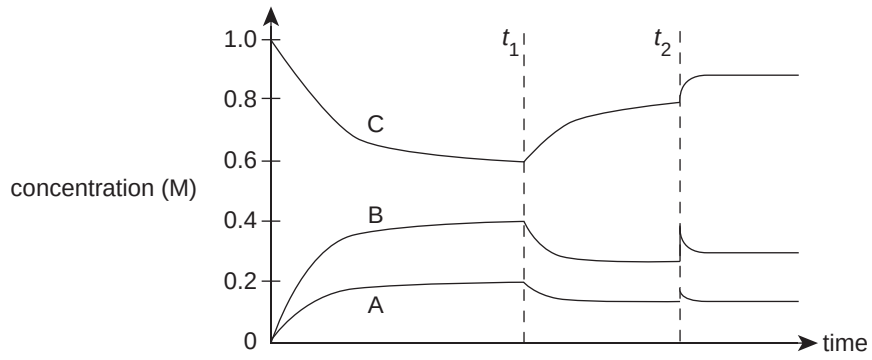
ii. $K = \dfrac{[NO]^2[Br_2]}{[NOBr_2]^2} = \dfrac{(0.0944)^2 \times 0.0472}{(0.306)^2} = 4.49 \times 10^{-3}$ M 1 mark

b. **i.** NO 1 mark

ii. increased 1 mark

At t_1 the concentration of $NOBr_2$ increased and the concentration of NO and Br_2 decreased. The reaction must have proceeded to the left to effect these concentration changes. As the forward reaction is exothermic, the temperature must have increased at t_1, as a temperature increase favours the endothermic (backwards) reaction. 1 mark

iii.



2 marks

A small quantity of NO was added at time t_2*. Addition of a product will cause the reaction to proceed to the left to partly compensate.*

To gain full marks the extension of the graph must show the proportional increase in concentration of the $NOBr_2$ *(C) with the decrease of NO (B) and* Br_2 *(A) in the ratio 1 : 1 : 0.5.*

Total 8 marks

Question 49

a. **i.** $n(Na_2SO_4.10H_2O) = \frac{m}{M} = \frac{25.0 \times 10^3}{322.1} = 77.6$ mol 1 mark

energy absorbed = $77.6 \times 78.2 = 6.07 \times 10^3$ kJ 1 mark

ii. $E = c \times m \times \Delta T$

$6.07 \times 10^6 = 4.18 \times 25\,000 \times \Delta T$

$\Delta T = 58.1°C$ 1 mark

b. **i.** $6CO_2(g) + 6H_2O(l) \xrightarrow[\text{light}]{\text{chlorophyll}} C_6H_{12}O_6(aq) + 6O_2(g)$ 1 mark

ii. For example:
The fuel is 'wet' and so does not produce large amounts of energy per gram of fuel. 1 mark

iii. For example:
It could be mixed with petrol as a fuel for combustion engines. 1 mark

c. It is difficult to obtain the high temperatures needed to initiate the reaction, and to contain the reaction at the very high temperatures generated. 1 mark

Total 7 marks

Question 50

a. **i.** Br_2 1 mark

ii. H_2O is a stronger oxidant than Mg^{2+}. 1 mark

In aqueous solution, water will be reduced to form hydrogen gas and hydroxide ions in preference to the reduction of magnesium ions to deposit magnesium. 1 mark

iii. For example,
$CuBr_2(aq)$ 1 mark

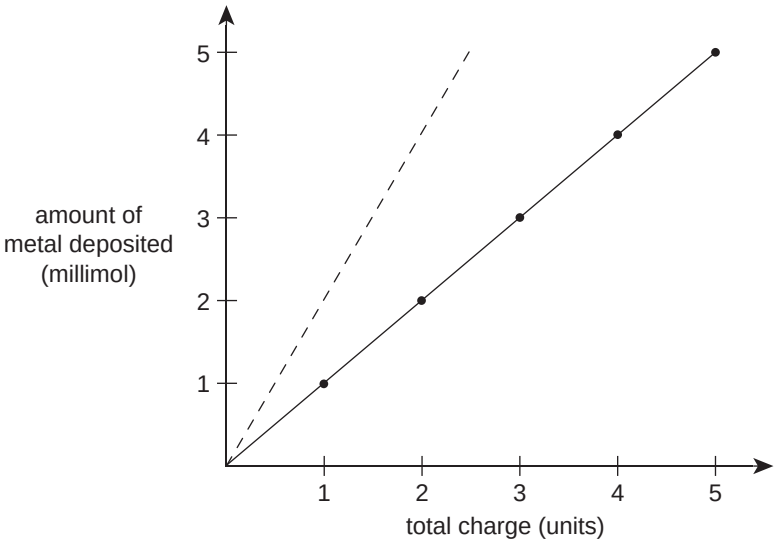
b. **i.** $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e$ 1 mark

ii. $n(O_2) = \dfrac{V}{V_M} = \dfrac{25.0}{24\ 500}$ mol 1 mark

$n(e) = 4 \times n(O_2)$ 1 mark

$t = \dfrac{n(e) \times F}{I} = \dfrac{4 \times \dfrac{25.0}{24\ 500} \times 96\ 500}{0.060} = 6565 \text{ s} = 109 \text{ min}$ 1 mark

c.



2 marks

Relevant half equations are $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ and $Ag^+(aq) + e^- \rightarrow Ag(s)$. For a given amount of charge (i.e. a given number of electrons) the amount, in mole, of Ag deposited will be twice that of Cu.

Total 10 marks