CHEMISTRY 11

UNIT 1

2019 Semester 1

MARKING GUIDE

Section One: Multiple-choice **(50 marks)**

1	a ■ b □ c □ d □
2	a □ b □ c □ d ■
3	a □ b ■ c □ d □
4	a □ b □ c □ d ■
5	a □ b □ c □ d ■

6	a □ b □ c □ d ■
7	a □ b ■ c □ d □
8	a ■ b □ c □ d □
9	a □ b □ c □ d ■
10	a □ b □ c ■ d □

11	a □ b ■ c □ d □
12	a □ b □ c ■ d □
13	a □ b ■ c □ d □
14	a ■ b □ c □ d □
15	a ■ b □ c □ d □

16	a ■ b □ c □ d □
17	a □ b □ c □ d ■
18	a □ b □ c ■ d □
19	a □ b ■ c □ d □
20	a ■ b □ c □ d □

21	a □ b □ c □ d ■
22	a □ b □ c ■ d □
23	a □ b □ c ■ d □
24	a ■ b □ c □ d □
25	a □ b □ c ■ d □

(2 marks per question)

Section Two: Short answer **35% (70 marks)**

This section has **8** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 60 minutes.

Question 26 **(5 marks)**

Complete the following table by writing either the name or formula for each substance.

Name	**Formula**
aluminium sulfite	**$Al_2(SO_3)_3$**
carbon tetrachloride OR tetrachloromethane	CCl_4
iron(II) hydroxide	$Fe(OH)_2$
phosphoric acid	**H_3PO_4**
lithium hydrogencarbonate (OR lithium bicarbonate)	$LiHCO_3$

Question 27 **(7 marks)**

Ethanol (C_2H_5OH) is a fuel that is produced by two main methods. The hydration of ethene produces ethanol, whilst the fermentation of glucose produces bioethanol. Ethanol and bioethanol are identical in structure, however bioethanol is classified as a biofuel.

(a) What is a 'biofuel'? Explain why biofuels produce a much lower level of overall carbon emissions compared to fossil fuels. (3 marks)

- **a fuel produced from biomass (a more fundamental description could be given)**
- **biomass has absorbed CO_2 from atmosphere, this is in turn released when the fuel is combusted**
- **therefore net production of CO_2 is near zero**

When liquid ethanol is combusted, it produces water vapour, carbon dioxide gas.

(b) Write a balanced **thermochemical** equation for this combustion process. Include phase symbols. (4 marks)

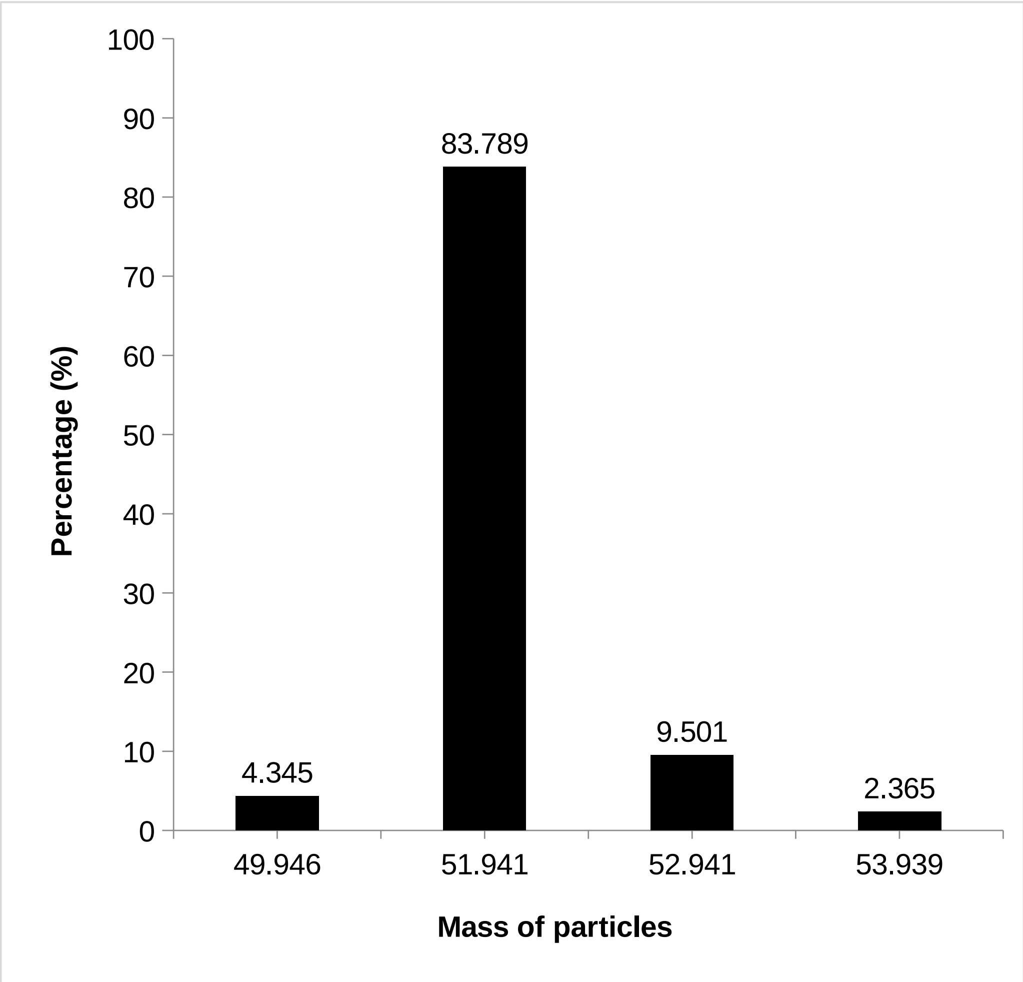
$$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 3\,H_2O(g) + 2\,CO_2(g) + \text{heat}$$

(or give ΔH -ve)

(1) reactant and product formulas shown correctly
(1) phase symbols
(1) balanced correctly
(1) heat shown as product / ΔH given as -ve

Question 28 **(9 marks)**

A pure sample of an element is isolated and analysed by mass spectrometry to determine its relative atomic mass. The data from this analysis is shown below.



The process of mass spectrometry involves 4 steps;

1. **ionisation**
2. **acceleration**
3. deflection
4. detection

(a) Write the names of the first 2 steps involved in mass spectrometry in the spaces above. (2 marks)

In step 3, the various particles are deflected based on their mass. (You may assume that all particles in the mass spectrometer have the same charge.)

(b) How are the particles deflected? (1 mark)

- **magnetic field / by a magnet**

(c) Explain how atoms of an element can have different masses, and elaborate on the composition of this element by using the graph on the previous page. (3 marks)

- **isotopes**
- **different numbers of neutrons therefore different masses**
- **graph shows 4 peaks therefore 4 isotopes**
  OR graph shows abundance of each isotope so therefore 51.941 is most common isotope
  (or any similar acceptable interpretation of graph)

(d) Calculate the relative atomic mass of the element. Identify this element by name or symbol. (3 marks)

Ar = (4.345 x 49.946 + 83.789 x 51.941 + 9.501 x 52.941 + 2.365 x 53.939) / 100
= 51.9966
= 52.00 (2)

Element is Cr / chromium (1)

Question 29 **(10 marks)**

Lead metal can be extracted from several different compounds, the most common of which is galena, or lead(II) sulfide (PbS). The overall process for the extraction of lead from an ore containing galena can be represented by the equation below.

$$2\ PbS(s) + 3\ O_2(g) + C(s) \rightarrow 2\ Pb(s) + 2\ SO_2(g) + CO_2(g)$$

If 327 kg of galena (PbS) was available;

(a) Calculate the mass of O_2(g) required to react with the PbS(s). (4 marks)

m(PbS) = 327×10^3 g

n(PbS) = m/M
= 327×10^3 / 239.27
= 1366.6569 mol

n(O_2) = n(PbS) x 3/2
= 2049.9854 mol

m(O_2) = nM
= 2049.9854 x 32
= 65599.5319 g
= 65.6 kg OR 6.56×10^4 g (3 SF)

(b) Calculate the maximum mass of Pb(s) that could be extracted from the PbS(s). (2 marks)

n(Pb) = n(PbS)
= 1366.6569

m(Pb) = nM
= 1366.6569 x 207.2
= 283171.31 g
= 283 kg OR 2.83×10^5 g (3 SF)

(c) If the ore is 69.3% galena, calculate the starting mass of ore required to provide the 327 kg of galena. (2 marks)

m(ore) = 327 x 100/69.3

= 471.86 kg
= 472 kg (3 SF)

Ore containing galena often also contains silver in small amounts. This too can be extracted and sold. If the mass of ore in part (c) was determined to contain 1.7% silver by mass;

(d) Calculate the maximum mass of silver that could also be extracted from this ore. Ensure that you give the correct number of significant figures. (2 marks)

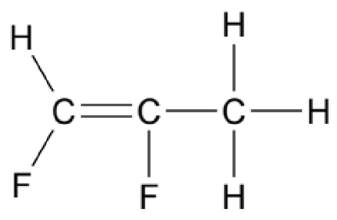
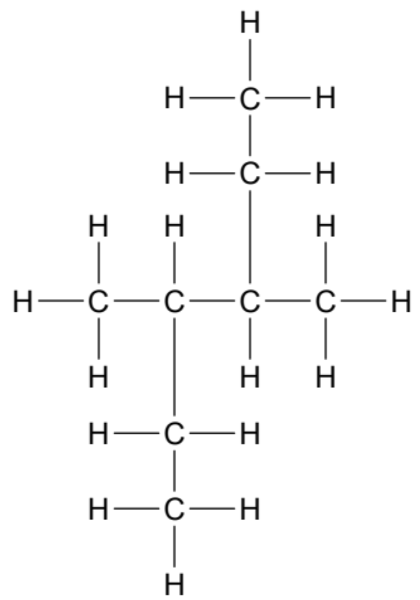
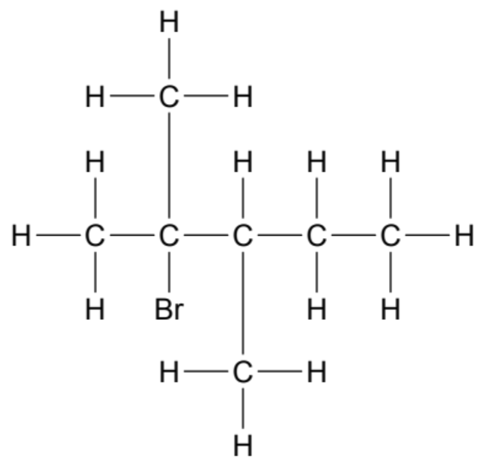
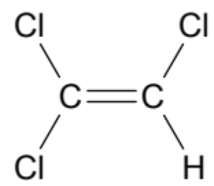
m(Ag) = 1.7/100 x 471.86

= 8.0216 kg
= 8.02 kg (3 SF)
= 8.0 kg (2 SF) - Must be given as 2 SF

Question 30 **(7 marks)**

A student was practising the naming and drawing of various organic compounds.

(a) Complete the table below by drawing structural formulas of the organic substances indicated. Structures should include all bonds. (4 marks)

<table>
<tr><td>(i) cis-1,2-difluoropropene
</td><td>(ii) 2,3-diethylbutane
</td></tr>
<tr><td>(iii) 2-bromo-2,3-dimethylpentane
</td><td>(iv) trichloroethene
</td></tr>
</table>

One of the substances in part (a) has been incorrectly named, i.e. the name has not been stated according to IUPAC rules.

(b) Which name is incorrect? Explain why the name is incorrect and give the appropriate IUPAC name for the substance. (3 marks)

- **(ii) is incorrect *students should get mark in (a) if they correctly explain why they cannot draw what is asked**
- **the longest carbon chain is 6, this should be the stem name**
- **3,4-dimethylhexane**

Question 31 **(10 marks)**

Ionic substance	Equation representing dissolution	Enthalpy of dissolution (H)
ammonium nitrate	$NH_4NO_3(s) \rightarrow NH_4^+(aq) + NO_3^-(aq)$	+25.69 kJ mol^{-1}
potassium hydroxide	$KOH(s) \rightarrow K^+(aq) + OH^-(aq)$	-57.61 kJ mol^{-1}
lithium bromide	$LiBr(s) \rightarrow Li^+(aq) + Br^-(aq)$	-48.80 kJ mol^{-1}

Some chemistry students were given a 3.0 g sample of each ionic substance in the table above. Unfortunately the samples were unlabelled and all appeared as white powders.

(a) Describe an experimental procedure by which the students could quickly identify $NH_4NO_3(s)$ from the other two samples. You may assume you have access to standard laboratory equipment, however no other chemicals are available. (4 marks)

- **place each sample in a separate beaker and add an equal amount of water to each to dissolve the powders (2 – only award one mark if students don't mention an 'equal amount of water in each' – specific quantities of water could be stated)**
- **use a thermometer to measure the temperature change in each**
- **solution where temperature decreases is NH_4NO_3**

The intention of the question is clearly to use the data in the table, but this is not explicitly stated, so a flame test meets the criteria. (it is also not explicitly stated that water is available for either test procedure).

- **Perform a flame test**
- **Satisfactory description of procedure**
- **Explain that different salts/solutes give different colours**
- **Clearly explain how NH_4NO_3 can be distinguished from the other salts (for example K lilac, Li red, NH_4NO_3 dull orange-yellow of the flame)**

Ammonium Nitrate

Burns in an orange flame, releasing a large amount of smoke. Needle is left clean. No distinct odor.

(b) What does the value of H for the dissolution of NH_4NO_3 indicate about the energy associated with the bond breaking and making involved in this process? (2 marks)

- **energy required to break the bonds is greater**
- **than the energy released when new bonds form**

(c) Compare by calculation, the energy change associated with the dissolution of 3.0 g of KOH(s) and LiBr(s). Use your calculations to explain how these 2 powders could therefore be distinguished from one another. (4 marks)

n(KOH) = m/M = 3.0 / 56.108
= 0.05346 mol

n(LiBr) = m/M = 3.0 / 86.84

= 0.03454 mol
(1)

E released(KOH) = 0.05346 x 57.61
= 3.080 kJ

E released(LiBr) = 0.05346 x 48.80
= 1.686 kJ
(1)

NB. 3.0 g is 2 SF, so really that is all that is justified in n, E answers!

KOH releases more heat than LiBr given the same mass (1)

Therefore KOH should measure a larger increase in temperature upon dissolution (1)
(the mass of water should be controlled ! – this is covered in a different context in (a))

Question 32 **(9 marks)**

The electron configuration of ‘Element Y’ is 2, 8, 5.

(a) What information does this electron configuration provide about the **period** in which Element Y is located? Justify your answer. (2 marks)

- **period 3**
- **electrons residing within first three shells**

(b) What information does this electron configuration provide about the **group** in which Element Y is located? Justify your answer. (2 marks)

- **group 15**
- **configuration shows 5 valence electrons**

(c) Identify Element Y by name or symbol. (1 mark)

- **phosphorus / P**

(d) Complete the following table. (4 marks)

	Symbol of element in the form $^{A}_{Z}X$	Electron configuration
An element in the same period as Y but with a smaller atomic radius	**$^{32}_{16}S$** **$^{35}_{17}Cl$** **$^{40}_{18}Ar$** **(or any other sensible A value)** But not the Ar value! -> zero	**2, 8, 6** **2, 8, 7** **2, 8, 8**

An element in the same group as Y that would have a higher first ionisation energy	$^{14}_{7}N$	**2, 5**

End of Section Two

Section Three: Extended answer **40% (80 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.
Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

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Suggested working time: 70 minutes.

Question 33 **(16 marks)**

A chemistry student had two unlabelled beakers, each containing a different colourless liquid. One contained hexane, $CH_3CH_2CH_2CH_2CH_2CH_3(l)$, and the other hex-1-ene, $CH_2CHCH_2CH_2CH_2CH_3(l)$.

The student added a few drops of liquid bromine, $Br_2(l)$, to each beaker in order to distinguish the liquids.

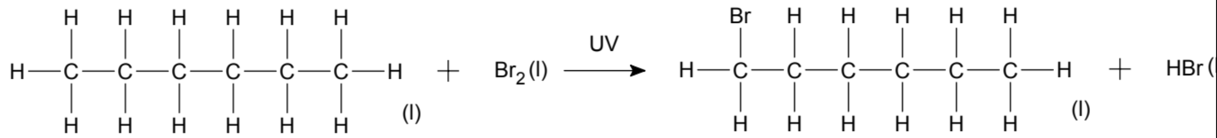
(a) Why is it important that the liquid bromine be limiting (i.e. only a few drops are added) for this distinguishing test to be effective? (2 marks)

- **must be limiting (limiting reagents have not been specifically covered by the syllabus, but the concept is valid) so that colour change with alkene can be observed (all** Br_2 **must react with the hexene)**
- **if present in excess then both solutions would appear red**

Whilst no immediate or visible reaction was observed to occur with the hexane, in the presence of an appropriate catalyst, a slow reaction has the potential to take place.

(b) Write a balanced equation for this reaction, including phase symbols, and name the type of reaction that is occurring. (4 marks)

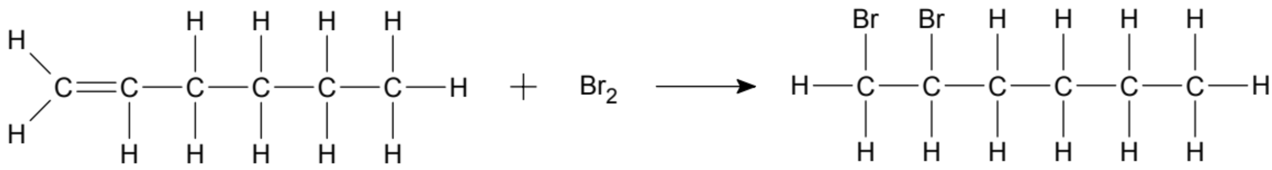
Equation:



Type of reaction: **substitution**

(1) reactants (1) products (1) catalyst* (1) substitution. (2-bromo or 3-bromohexne could also form

The equation for the reaction with liquid hex-1-ene is shown below.



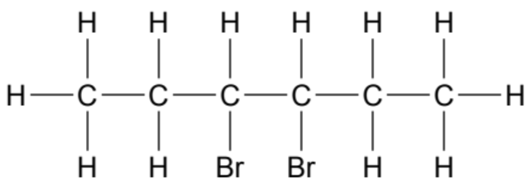
If 8 drops of bromine liquid are added to the beaker containing hex-1-ene and shaken;

(c) Calculate the mass of 1,2-dibromohexane produced. You can assume 1 drop of bromine liquid = 0.05 g. (4 marks)

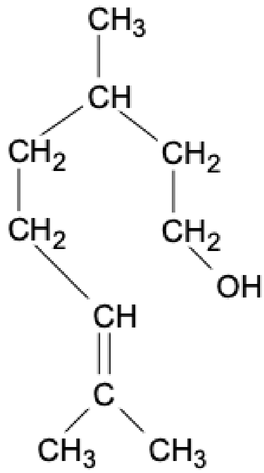
m(Br_2)	**=**	**8 x 0.05**
	=	**0.4 g**
n(Br_2)	**=**	**m/M**
	=	**0.4 / 159.8**
	=	**0.00250313 mol**
n($C_6H_{12}Br_2$)	**=**	**n(Br_2)**
	=	**0.00250313 mol**
m($C_6H_{12}Br_2$)	**=**	**nM**
	=	**0.00250313 x 243.956**
	=	**0.610653 g**
	=	**0.6 g (1 SF) (accept up to 3 SF)**

If hex-3-ene had been used in place of hex-1-ene in the reaction above;

(d) Draw and name the product of the reaction. (2 marks)

Structural diagram:	IUPAC name:
	**3,4-dibromohexane**

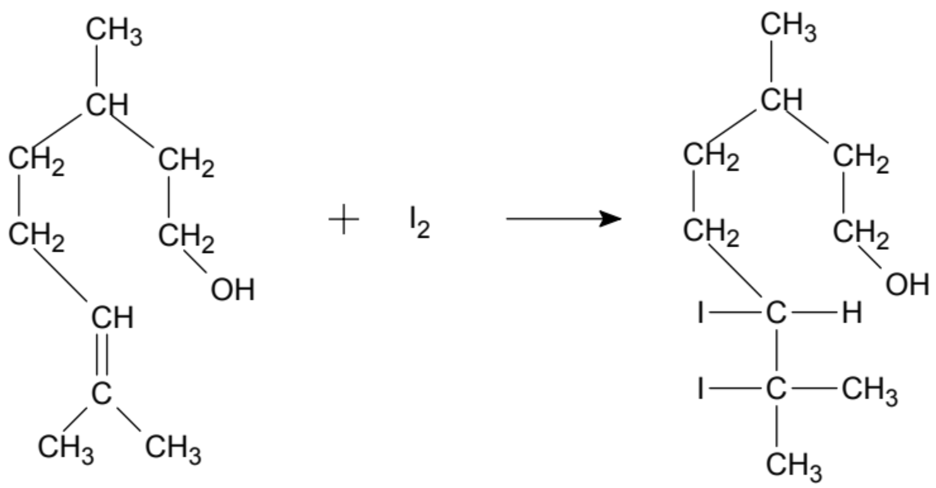
The organic substance ‘citronellol’ is found in citronella and essential oils isolated from lemongrass. It is used in soaps, candles, incense, cosmetics and insect repellents. A molecule of citronellol is shown below.



A pure sample of liquid citronellol was mixed with a few drops of iodine water, $I_2(aq)$.

(e) Write a balanced equation for the reaction that would take place and name the type of reaction occurring. (2 marks)

Equation:



Type of reaction: **addition**

(f) Calculate the percent by mass of carbon in citronellol. (2 marks)

MF(citronellol) = $C_{10}H_{20}O$
M(citronellol) = 10 x 12.01 + 20 x 1.008 + 16 = 156.26

%C = (10 x 12.01) / 156.26 x 100
= 76.859%
= 76.86% (4 SF)

Question 34 **(6 marks)**

Allotropes are defined as the different physical forms in which an element can exist. Allotropes will be composed of the same element but the atoms will be arranged in structurally distinct ways. The two major allotropes of carbon are diamond and graphite. Fullerenes are a group of substances also classified as allotropes of carbon. The structure and properties of fullerenes are varied, but one particularly unique fullerene is the 'buckyball'.

Buckyballs have the formula C_{60} and consist of carbon atoms arranged in the shape of a soccer ball. They are found in soot and appear as dark grey crystals in pure form. Buckyballs have high melting and boiling points and are semi-conductors. Buckyballs are also classified as nanomaterials.

(a) Define a 'nanomaterial' and name one other nanomaterial that is a fullerene. (2 marks)

- **materials containing particles in the size range 1-100 nm**
- **carbon nanotubes, buckytubes… etc**

A chemist isolated a pure sample of buckyballs weighing 3.8 mg.

(b) Calculate
(i) the number of buckyballs, and
(ii) the number of carbon atoms
that would be present in this sample. (4 marks)

$m(C_{60})$ = 3.8×10^{-3} g = 0.0038 g

$n(C_{60})$ = m/M
= 0.0038 / (60 x 12.01)
= 5.2734×10^{-6} mol

$N(C_{60})$ = n x Av
= $5.2734 \times 10^{-6} \times 6.022 \times 10^{23}$
= 3.176×10^{18} buckyballs
= 3.2×10^{18} buckyballs (2SF)

N(C) = $3.176 \times 10^{18} \times 60$
= 1.905×10^{20} atoms
= 1.9×10^{20} atoms (2SF)

Question 35 **(11 marks)**

Atomic absorption spectroscopy (AAS) can be used to determine the concentration of calcium (Ca^{2+}) in a patient's blood serum. Measurement of Ca^{2+} concentration is important in the diagnosis of various medical conditions.

During the process of AAS, the hollow cathode lamp produces a unique calcium emission spectrum, which is then passed through the atomised blood serum sample.

(a) Explain how the calcium present in the cathode of the hollow cathode lamp produces this emission spectrum. (4 marks)

- **the electrons in calcium absorb energy**
- **move to higher energy levels / atoms become excited**
- **as the electrons move back down / as atoms return to ground state**
- **energy is released as an emission spectrum from the hollow cathode lamp**

(b) How is a measure of concentration obtained from this emission spectrum? (3 marks)

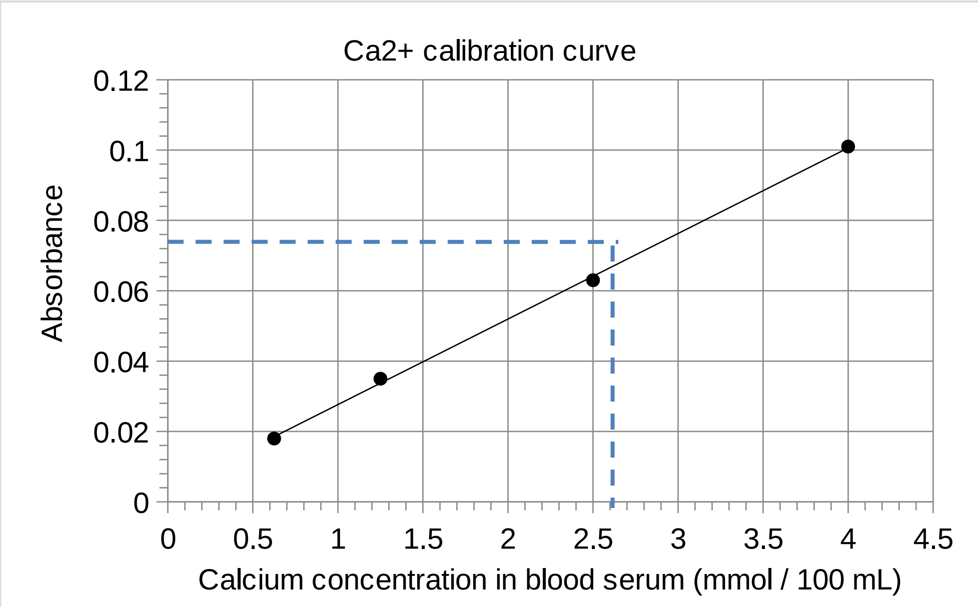
- **any calcium present in the sample to be analysed will absorb the wavelengths in the emission spectrum**
- **the detector measures how much light passes through the sample**
- **a higher amount of absorption means a higher concentration of calcium**

The healthy or 'normal' range of Ca^{2+} concentration in blood serum is generally between 2.2 - 2.6 mmol / 100 mL (millimoles per 100 millilitres).

'Hypocalcaemia' i.e. low concentrations of serum calcium, can be associated with vitamin D deficiency or renal disease. 'Hypercalcaemia; i.e. high concentrations of serum calcium, can cause hair loss, insomnia, muscle fatigue and joint pain.

Patients with results lower than 2.2 mmol / 100 mL are classified as 'hypocalcaemic', whilst those with results above 2.6 mmol / 100 mL are classified as 'hypercalcaemic'.

To determine the Ca^{2+} concentration using AAS, the patients' blood samples were compared to an existing calibration curve. This curve was obtained by performing AAS on a series of standards with known Ca^{2+} concentrations. Absorbance readings were taken at 422.7 nm.



A patient's blood sample recorded an absorbance reading of 0.074.

(c) Determine the concentration of Ca^{2+} in the patient's blood in mmol / 100 mL. Based on this result, would the patient be classified as having 'hypocalcaemia', 'hypercalcaemia' or 'normal' calcium levels? (2 marks)

- **from graph, 2.9 mmol / 100 mL**
- **hypercalcaemia**

If a patient's result is classified as hypocalcaemic or hypercalcaemic, a second blood sample is taken and the test is conducted again.

(d) Give two reasons why this would be done. (2 marks)

- **to ensure first result was accurate, ensure no error or false reading had been made, to reduce the chance of error, increase reliability of test, safety reasons before patient is diagnosed/medication prescribed etc… (any 2)**

Question 36 **(14 marks)**

Portable Bunsen burners use canisters of butane as their fuel source. Typically the canisters contain 220 g of butane and state that they provide 2.5 hours of burn time.

The chemical reaction that takes place when a portable Bunsen burner is being used is shown below.

$$2\ C_4H_{10}(g)\ +\ 13\ O_2(g)\ \rightarrow\ 8\ CO_2(g)\ +\ 10\ H_2O(g)\ +\ 5755\ kJ$$

Assuming you begin with a full canister containing 220 g of butane, and oxygen is consumed from the air at a rate of 4.772 g min^{-1};

(a) Calculate the burn time of the canister (i.e. how long will the Bunsen burner be able to function before the fuel runs out?) and comment on whether the advertised burn time is accurate. (6 marks)

OR

n(C_4H_{10}) = m/M #
of mins = 2.5 x 60
= 220 / 58.12
= 150 mins
= 3.78527 mol
m(O_2 cons'd) = 150 x 4.772

= 715.8 g
n(O_2 req'd) = n(C_4H_{10}) x 13/2

= 24.60427 mol
n(O_2 cons'd) = m/M

= 715.8 / 32
m(O_2 req'd) = nM
= 22.36875 mol
= 24.60427 x 32

= 787.3365 g
n(C_4H_{10} req'd) = n(O_2) x 2/13

= 3.4413 mol
# of mins = 787.3365 / 4.772
= 165 mins

m(C_4H_{10}) = nM
= 3.4413 x 58.12
= 166 g

165 mins is greater than 2.5 hours

Therefore you would get a longer burn time than stated / burn time is inaccurate.

166 g is less than the 220 g provided

Therefore you would get a longer burn time than stated / burn time is inaccurate.

Air is comprised of 21.0% oxygen gas by mass.

(b) Calculate the mass of air that would have been required to provide enough oxygen for the entire canister of butane to be combusted. (2 marks)

$m(O_2)$ = 787.3365 g [from part (a)]

m(air) = 787.3365 x 100/21
= 3749.22 g
= 3.75 kg OR 3.75×10^3 g (3 SF)

(c) Calculate the total amount of energy released in the combustion of the entire canister of butane. (2 marks)

energy produced = $n(C_4H_{10})$ x 5755 / 2

= 3.78527 x 5755 / 2 [$n(C_4H_{10})$ = 3.78527 mol from part (a)]
= 10892 kJ
= 1.09×10^4 kJ OR 10.1 MJ (3 SF)

Non-portable Bunsen burners used in the laboratory are joined to a gas tap where methane is the fuel source. The enthalpy of combustion for this fuel is 882 kJ mol^{-1} of methane.

(d) Write a balanced **thermochemical** equation for the complete combustion of methane (assume excess oxygen gas is present). (2 marks)

$$CH_4(g) + 2\,O_2(g) \rightarrow CO_2(g) + 2\,H_2O(g) + 882\text{ kJ}$$

(1) balanced
(1) enthalpy shown

If you wanted to produce the same amount of energy as that produced by a canister of butane;

(e) Calculate the mass of methane required. (2 marks)

$n(CH_4)$ = 10892 / 882
= 12.349336 mol

$m(CH_4)$ = nM
= 12.349336 x 16.042
= 198.108 g
= 198 g (3 SF)

*** award follow through marks for part (e) if part (c) is incorrect**

Both methane and butane are extracted from crude oil, which is a fossil fuel.

Question 37 **(16 marks)**

Sodium (Na), magnesium (Mg), sulfur (S_8) and chlorine (Cl_2) are all elements located in period 3 of the Periodic Table.

(a) State and explain the trend in electronegativity across period 3. (3 marks)

- **electronegativity increases across period 3**
- **an increase in the number of protons in the nucleus and a decrease in atomic radius**
- **means that the period 3 elements attract electrons more strongly (from left to right) i.e. have a higher electronegativity**

Sodium and magnesium are both good conductors of electricity while sulfur and chlorine are not.

(b) Explain this difference in terms of the structure and bonding of the species present in these elements. (3 marks)

- **Na and Mg are both metallic**
- **The delocalised electrons act as mobile charge carriers**

- **S_8 and Cl_2 are covalent molecules that have no mobile charge carriers**

Consider two of the ionic compounds that could form from these elements; sodium chloride ($NaCl$) and magnesium sulfide (MgS).

(c) Using the concepts of ionisation energy and electronegativity, explain how the chemical bonds within $NaCl$ or MgS form. (4 marks)

- **Na/Mg have low ionisation energy, i.e. small amount of energy required to remove electron**
- **Cl/S have high electronegativity, i.e. exert strong attraction on an electron**
- **The metallic Na/Mg will therefore easily donate 1 or 2 electrons respectively to the non-metals**
- **The oppositely charged metal cations and the non-metal anions will now attract and form ionic bonds**

Sodium chloride is soluble in water, where as magnesium sulfide is not. A student was given a mixture of these two white powders.

(d) Briefly list the steps the student could use to separate the 2 compounds, resulting in isolation of pure samples of each solid. Alternately you may choose to use a series of clearly labelled diagrams or a flow chart to outline an appropriate method. (6 marks)

- **add excess water to the powders and stir**
- **pour mixture through filter funnel lined with filter paper**
- **the $MgS(s)$ will be the residual solid remaining in the filter paper**
- **wash and dry MgS**
- **the filtrate will be $NaCl(aq)$**
- **evaporate the water, leaving $NaCl(s)$**

*** accept any answer format that clearly outlines these separation processes, resulting in the two powders being isolated, and any other valid and reasonable method.**

End of questions