Answer ALL questions. Write your answers in the spaces provided.

1 New elements can be made by scientists.

One new element has recently been given the name nihonium.

(a) The atomic number of nihonium is 113

What does this indicate about nihonium?

(1)

☒ **A** a nihonium atom has 113 protons

☒ **B** a nihonium atom has 113 neutrons

☒ **C** nihonium has a relative atomic mass of 113

☒ **D** nihonium is a non-metal

atomic number ⇒ number of p^+

(b) Nihonium has been placed in Group 3 of the Periodic Table.

It has been given the symbol Nh

(i) State the number of electrons in the outer shell of a nihonium atom.

(1)

3 (group number = no. of e^- in outer shell)

(ii) State why nihonium has been given the symbol Nh, and not N or Ni

(1)

- N already used for nitrogen (and Ni used for nickel)

(c) Nihonium has many isotopes.

One of these isotopes is ^{286}Nh

(i) State what is meant by the term **isotopes**.

(2)

- atoms (of the same element) with the same number of protons
- but a different number of neutrons

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(ii) How many neutrons are there in an atom of ^{286}Nh?

(1)

☒ **A** 113

☒ **B** 173

☒ **C** 286

☒ **D** 399

286 − 113 = 173

(d) Gallium is another element in Group 3. It has two isotopes, ^{69}Ga and ^{71}Ga

A sample of gallium contains 60.1% ^{69}Ga and 39.9% ^{71}Ga

Calculate the relative atomic mass of this sample of gallium, giving your answer to one decimal place.

(3)

$$\frac{(60.1 \times 69) + (39.9 \times 71)}{100}$$

$$= \frac{6979.8}{100} = 69.79$$

relative atomic mass = 69.8

(Total for Question 1 = 9 marks)

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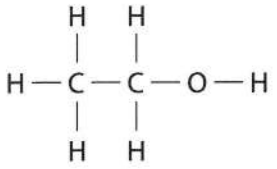
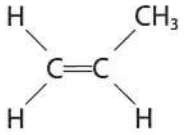
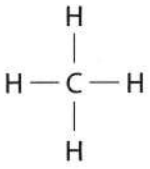
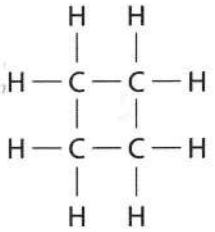
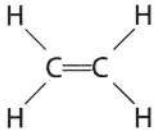
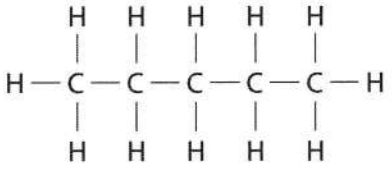
2 The table shows some carbon compounds.

P 	**Q** 
R 	**S** 
T 	**U** 

(a) Which compound is **not** a hydrocarbon?

(1)

- ☒ **A** compound **P** (contains oxygen)
- ☒ **B** compound **Q**
- ☒ **C** compound **S**
- ☒ **D** compound **T**

(b) Give the empirical formula of compound **T**.

(1)

CH_2

(c) What is the name of compound **U**?

(1)

☒ **A** propane

☒ **B** propene

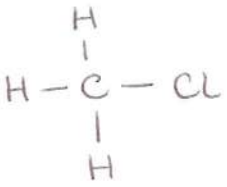
☒ **C** pentane (5 carbons, no double bonds)

☒ **D** pentene

(d) Compound **R** reacts with chlorine in the presence of ultraviolet radiation.

Draw the displayed formula of the organic compound made.

(1)



(e) The molecular formula of compound **S** is C_4H_8

Student X states that compound **S** is an alkane.

Student Y states that compound **S** is an alkene.

Comment on each of the student's statements.

(4)

- Student X is accurate as:
  - S does not have a carbon = carbon double bond
  - so S cannot be an alkene
- Student Y is accurate as:
  - S fits the general formula of C_nH_{2n}
  - which is the general formula for alkenes

(Total for Question 2 = 8 marks)

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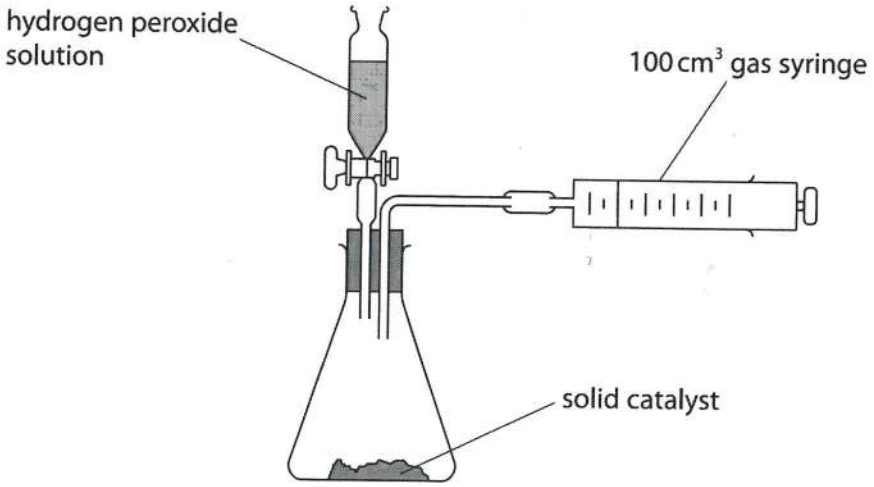
3 Hydrogen peroxide, H_2O_2, is a solution that decomposes slowly.

A student uses this apparatus to investigate the rate of decomposition of hydrogen peroxide.



(a) Complete the chemical equation for the decomposition of hydrogen peroxide.

(1)

2 $H_2O_2(aq) \rightarrow$ 2 $H_2O(l)$ + ... $O_2(g)$

(b) This is the student's method.

- add 10 cm^3 of hydrogen peroxide solution to the conical flask using the funnel
- measure the time it takes to collect 20 cm^3 of oxygen
- repeat using 10 cm^3 of hydrogen peroxide solution of different concentrations

State two variables that the student should control in his investigation.

(2)

1 temperature

2 mass of catalyst

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(c) The student makes the different concentrations of hydrogen peroxide solution by adding water.

The table shows some of the student's results.

Volume of hydrogen peroxide solution in cm^3	Volume of water added in cm^3	Time taken to collect 20 cm^3 of oxygen in s
10	0	15
8	2	19
6	4	26
4	6	
2	8	75

(i) Explain why he does not do an experiment with 0 cm^3 of hydrogen peroxide solution and 10 cm^3 of water.

(2)

• No oxygen would be produced

• as there would be no hydrogen peroxide to decompose

(ii) Calculate the mean rate of oxygen production, in cm^3 per second, for the reaction with 6 cm^3 of hydrogen peroxide solution and 4 cm^3 of water.

(2)

$$\text{rate} = \frac{cm^3}{s}$$

$$= \frac{20}{26} = 0.77$$

rate = 0.77 cm^3 per second

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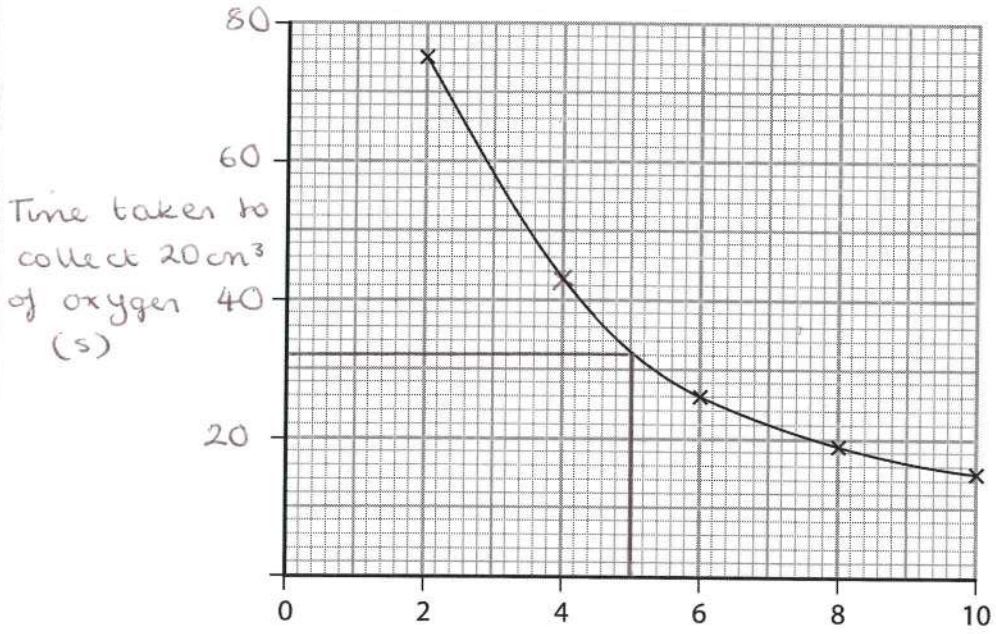
(iii) He uses his results to plot this graph.



Complete the graph by adding a scale and labelling the *y*-axis.

(2)

(iv) In the experiment using 4 cm^3 of hydrogen peroxide solution and 6 cm^3 of water, the student did not close the tap on the funnel after adding the solution.

Plot a point on the graph to show a possible result for this experiment.

(1)

(v) A solution containing 5 cm^3 of hydrogen peroxide and 5 cm^3 of water was decomposed.

Use the graph to determine the time taken to collect 20 cm^3 of oxygen.

Show on the graph how you obtain your answer.

(2)

time = 32 s

(d) The original hydrogen peroxide solution was labelled as a 10 volume solution.

A 10 volume solution produces a volume of oxygen ten times greater than the volume of solution used.

Suggest what might happen if the student used more than 10 cm^3 of hydrogen peroxide solution in his first experiment.

(2)

- 10 cm^3 of a 10 volume solution would produce 100 cm^3 of oxygen
- 100 cm^3 is the maximum capacity for the gas syringe

(Total for Question 3 = 14 marks)

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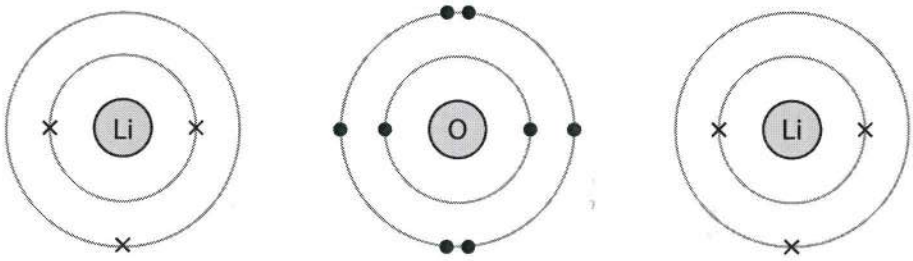
4 The elements in Group 1 of the Periodic Table react with oxygen to form different oxides.

(a) Lithium reacts with oxygen to form lithium oxide, Li_2O

The diagram shows the arrangement of the electrons in two lithium atoms and an oxygen atom.



Draw a dot-and-cross diagram to show the arrangement of the electrons in the ions in lithium oxide.

(3)

(b) 1.38 g of sodium is burned in oxygen. The product is an oxide of mass 2.34 g.

(i) Calculate the empirical formula of this oxide.

(3)

Na	O
1.38	0.96
23	16
0.06	0.06
0.06	0.06
1	1

empirical formula = NaO

(ii) The oxide has a relative formula mass of 78

Determine the molecular formula of the oxide.

(1)

23 + 16 = 39 $\frac{78}{39} = 2$ the molecular formula is Na_2O_2

(c) Potassium can react with oxygen to form potassium superoxide, KO_2

(i) The equation shows the reaction of this oxide with water.

$$2KO_2 + 2H_2O \rightarrow 2\ KOH + H_2O_2 + O_2$$

Complete the equation to show the missing product.

(1)

(ii) Potassium superoxide reacts with carbon dioxide to produce potassium carbonate and oxygen.

$$4KO_2 + 2CO_2 \rightarrow 2K_2CO_3 + 3O_2$$

5.5 million tonnes of carbon dioxide are released into the atmosphere each day as a by-product of the extraction of iron.

Calculate the mass, in tonnes, of potassium superoxide needed to react with this mass of carbon dioxide.

(3)

	CO_2	KO_2
mass	5 500 000	17 750 000
Mr	44	71
mol	125 000	250 000
ratio	2	4

(mol: 125 000 → 250 000, ×2; ratio: 2 → 4, ×2)

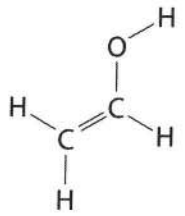
17 750 000 g ⇒ tonnes = 17.75

mass = 17.75 tonnes

(Total for Question 4 = 11 marks)

5 Polyvinyl alcohol (PVA) is a polymer that can be used to make slime for special effects in films.

The monomer for PVA is commonly called vinyl alcohol.



(a) The IUPAC names of all alcohols end with -ol.

What is the IUPAC name for vinyl alcohol?

(1)

- ☒ **A** ethanol
- ☒ **B** ethenol (has double bond and O–H bond)
- ☒ **C** propanol
- ☒ **D** propenol

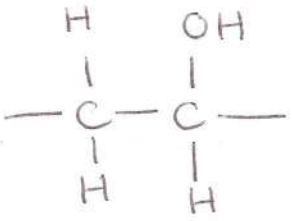
(b) Explain the colour change observed when bromine water is added to a solution of vinyl alcohol.

(2)

- bromine water turns colourless
- since vinyl alcohol has a carbon – carbon double bond

(c) Draw the repeat unit of the PVA polymer.

(2)



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(d) A typical molecule of PVA has a relative molecular mass of 27 500

Calculate the number of repeat units in this molecule of PVA.

(2)

Mr of repeat unit = (12 × 2) + (4 × 1) + 16
= 44

$\frac{27500}{44} = 625$

(e) Pure PVA melts at a temperature of 200 °C.

State how the melting point of an impure sample of PVA would be different to that of a pure sample.

(1)

• impure PVA would melt over a range of different temperatures

(Total for Question 5 = 8 marks)

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6 *Ming fan* is used in Chinese medicine. It is a mixture of substances, including a compound called alum.

A student is told that alum is also known as potassium aluminium sulfate.

She does three tests on a sample of *ming fan* to show that it contains potassium ions, aluminium ions and sulfate ions.

(a) The first test is a flame test.

What colour flame is produced?

(1)

☒ **A** green

☒ **B** lilac (potassium buns with 'lilac' flame)

☒ **C** red

☒ **D** yellow

(b) In the second test, she adds a solution of sodium hydroxide to a solution of *ming fan*.

She uses this test to show that *ming fan* contains aluminium ions.

The result is a white precipitate of aluminium hydroxide, $Al(OH)_3$

Write an ionic equation for the formation of aluminium hydroxide.

Include state symbols in your equation.

(2)

$Al^{3+}_{(aq)} + 3OH^{-}_{(aq)} \rightarrow Al(OH)_{3(s)}$

(c) The third test is for the sulfate ion.

Describe how the student should do this test.

(3)

test • add hydrochloric acid

• add barium chloride solution

result white precipitate

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(d) The ions present in alum are K^+, Al^{3+} and SO_4^{2-}
Crystals of alum also contain water of crystallisation.

Alum has the formula $K_xAl_y(SO_4)_z.nH_2O$

(i) Use the formulae of the ions in alum to suggest values for x, y and z in the chemical formula of alum.

(1)

x 1

y 1

z 2

(ii) Calculate the value of n in the chemical formula of alum.
[relative formula mass of alum = 474]

(3)

$Mr\ (KAl(SO_4)_2 = 39 + 27 + 2 \times (32 + (4 \times 16))$

$= 258$

$mass\ (H_2O) = 474 - 258 = 216$

$mol = \frac{mass}{Mr} = \frac{216}{18} = 12$

n = 12

(Total for Question 6 = 10 marks)

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7 The table gives some information about three elements in Group 7 of the Periodic Table.

Name	State at room temperature	Colour	Boiling point in °C
chlorine	gas	pale green	−35
bromine	liquid	red-brown	
iodine	solid	dark grey	184

(a) Use the information from the table to predict the boiling point of bromine.

(1)

boiling point = 80 °C

(b) Fluorine is above chlorine in Group 7.

Predict the colour and state of fluorine at room temperature.

(2)

colour pale yellow

state gas

(c) Bromine reacts with iron(II) ions.

$$Br_2(aq) + 2Fe^{2+}(aq) \rightarrow 2Br^-(aq) + 2Fe^{3+}(aq)$$

(i) Explain why this reaction is described as a redox reaction.

(2)

- bromine gains electrons, so are reduced
- Fe^{2+} ions lose electrons, so are oxidised

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(ii) Other elements in Group 7 may also react with Fe^{2+} ions.

Describe an experiment to find out if chlorine reacts with Fe^{2+} ions.

Your answer should include

- an outline method
- a test for showing if Fe^{2+} ions have reacted
- any relevant safety precautions.

(6)

- need a solution of iron (II) ions (e.g. iron (II) nitrate)
- chlorine water is added to solution
- sodium hydroxide solution added also
- if Fe^{2+} did not react, a green precipitate is formed
- if Fe^{2+} did react, a brown precipitate is formed
- safety glasses should be used for use of sodium hydroxide

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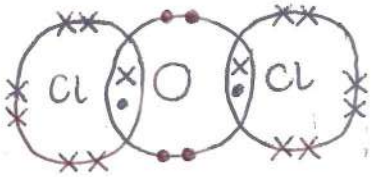
(d) Chlorine forms a covalent oxide called chlorine(I) oxide, Cl_2O

(i) Draw a dot-and-cross diagram to show the arrangement of electrons in a Cl_2O molecule.

Show only the outer electrons.

(3)



(ii) Chlorine(I) oxide reacts with water to form a solution.

Suggest a value for the pH of this solution.

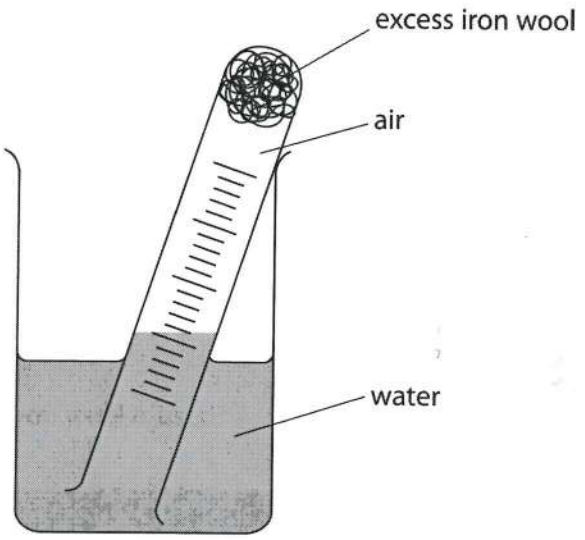
Give a reason for your answer.

(2)

- pH would be below 7
- chlorine is a non-metal (and non-metal oxides react with water to form acidic solutions)

(Total for Question 7 = 16 marks)

8 This apparatus is used to determine the percentage of oxygen in air.



A teacher sets up the apparatus and records the initial volume of gas in the tube.

When the level of water in the tube becomes constant, he records the final volume of gas in the tube.

(a) Suggest the time taken for the volume of gas in the tube to become constant.

(1)

☒ **A** 1 second

☒ **B** 1 minute

☒ **C** 1 week

☒ **D** 1 year

(b) Other than changes to the levels of water in the apparatus, state one other observation that would be made at the end of the experiment.

(1)

iron wool becomes rusty

(c) The teacher adjusts the apparatus before recording the volume of gas in the tube.

Explain the change that he makes.

(2)

- Tube needs to be held upright
- so that the scale can be accurately read

(d) The teacher does the experiment four times.

The table shows his results.

Initial volume in cm^3	Final volume in cm^3	Percentage of oxygen in air
32	26	
30	24	20%
27	22	19%
22	18	18%

(i) Calculate the percentage of oxygen in the air in the first experiment.

(2)

$$\frac{32-26}{32} \times 100 = 18.75$$

percentage = 19 %

(ii) Although the mean percentage of oxygen in these experiments is 19%, the teacher states that this value may not be accurate.

Comment on this statement.

(2)

- Volume can only be recorded to the nearest $1 cm^3$
- so a small error in reading off the measurement will give a very different value.

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(e) Explain the effect, if any, on the calculated percentage of oxygen in air when these changes are made.

(i) The iron wool is left for a shorter period of time.

(2)

- percentage of oxygen would be lower
- because some oxygen would not have yet reacted with the iron

(ii) A larger piece of iron wool is used.

(2)

- no change in percentage of oxygen
- because the iron wool is already in excess

(Total for Question 8 = 12 marks)

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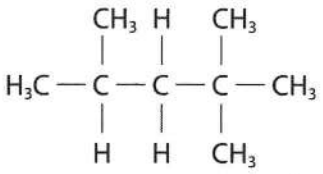
9 Crude oil can be separated into different fractions. These fractions can be used as fuels, or as raw materials for the chemical industry.

The gasoline fraction is used to make fuel for cars.

(a) The diagram shows the structural formula of a compound in gasoline.



Which hydrocarbon is an isomer of this compound?

(1)

☒ **A** pentane

☒ **B** hexane

☒ **C** heptane

☒ **D** octane (there are 8 carbons in the formula)

(b) Car exhaust fumes contain a number of different gases, including water vapour, carbon dioxide and carbon monoxide. These gases form when the fuel burns in the engine.

(i) Another gas is the largest component of car exhaust fumes.

Suggest the identity of this gas.

(1)

nitrogen

(ii) Car exhaust fumes also contain some nitrogen oxides.

State one effect that nitrogen oxides have on the atmosphere.

(1)

produces acid rain

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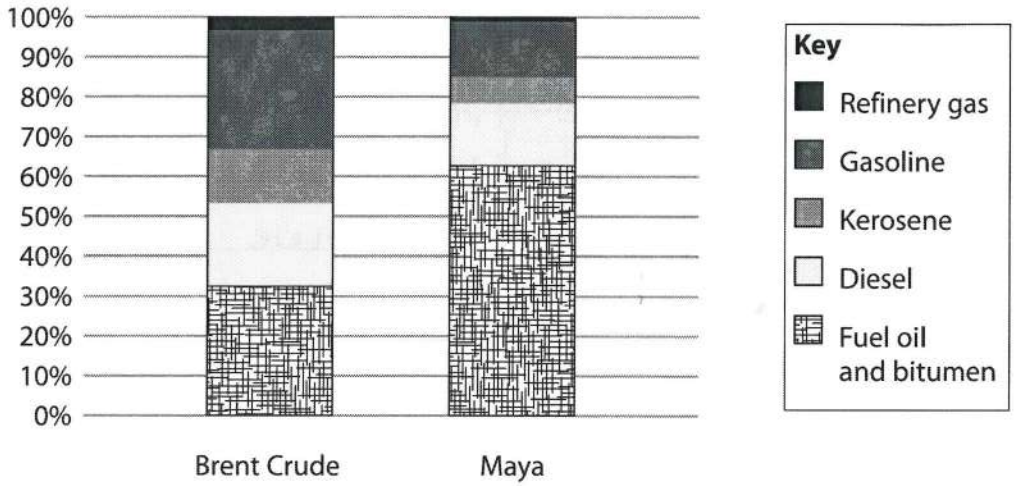
(iii) Explain why car exhaust fumes contain both carbon dioxide and carbon monoxide.

(3)

- The fuel reacts with oxygen
- this can happen via complete combustion to produce carbon dioxide
- can also happen via incomplete combustion to produce carbon monoxide

(c) Different crude oils have different compositions.

The diagram shows the composition of two different crude oils.



The table shows the price of each type of oil.

Crude oil	Brent Crude	Maya
Price per barrel	$63	$51

Discuss why Brent crude oil and Maya crude oil have different prices.

Use information from the diagram in your answer.

(3)

- Brent crude has a higher proportion of lighter fractions (eg. gasoline)
- Lighter fractions have more demand
- Therefore, Brent crude has a higher price than Maya crude oil.

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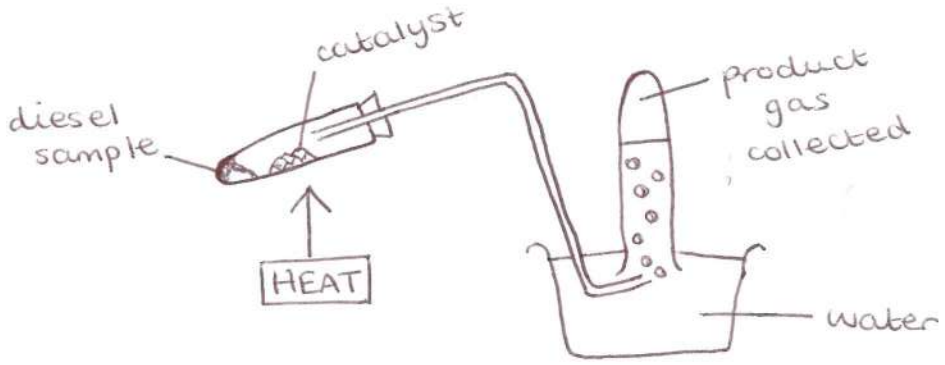
(d) Describe, using a labelled diagram, how a sample of the diesel fraction can be cracked in a laboratory to produce a gaseous alkene.

(4)



- diesel sample is in test tube
- heat is supplied
- catalyst present
- suitable method for collection (eg. over water)

(Total for Question 9 = 13 marks)

10 Most silver-coloured coins do not contain silver, but are made from a mixture of other metals.

(a) Describe the difference between a compound and a mixture.

(2)

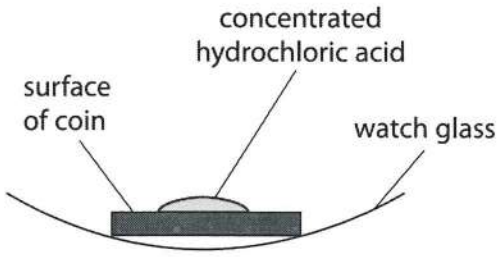
- In a compound, elements are chemically combined together
- in fixed proportions

(b) A student uses chromatography to investigate the metals present in a silver-coloured coin.

She places the coin on a watch glass.

She adds two drops of concentrated hydrochloric acid to the coin.

No visible reaction takes place, but the metals on the surface of the coin slowly react with the acid to form a solution.



(i) Which type of salt is formed when the metals in the coin react with the acid?

(1)

- ☒ **A** chlorate
- ☒ **B** chloride
- ☒ **C** chlorite
- ☒ **D** hypochlorite

(ii) The student states that there is no magnesium in the surface of the coin.

Explain why she is correct.

(2)

- magnesium is reactive so would react with the acid
- but there is only a slow reaction when acid is added to the coin

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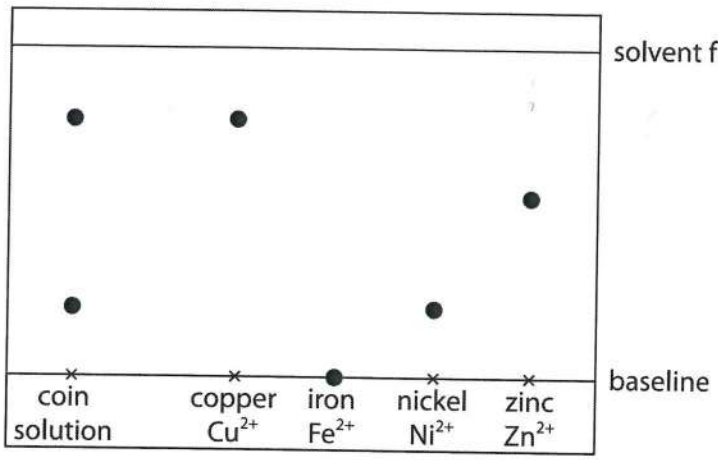
(c) The student places a spot of solution from the coin on a piece of chromatography paper.

Four other spots, each containing a different metal ion, are placed on the paper.

The bottom of the paper is placed in a solvent for some time. The paper is then removed and dried.

The results are shown in the diagram.



(i) The spots on the baseline are made as small as possible.

Suggest a reason for this.

(1)

prevents spots merging with each other

(ii) State why the spot containing Fe^{2+} ions stays on the baseline.

(1)

The iron salt is insoluble in the solvent used.

(iii) Explain which metals are present in the coin.

(2)

- nickel and copper
- Rf values of these samples are the same as spots in the coin solution

(Total for Question 10 = 9 marks)

TOTAL FOR PAPER = 110 MARKS