BENENDEN

SIXTH FORM 2018

CHEMISTRY

1 hour 30 minutes

Full Name: _____

Current School: _____

Date: _____

Instructions to Candidates:

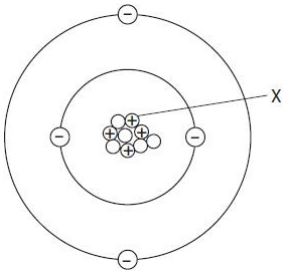
- Use black ink or ball point pen. If you change your mind about an answer please put a line through it and then write your new answer (no Tipex or correction fluid please)
- Answer **all** questions
- Answer the questions in the space provided
- Show all of the steps in any calculations and remember to include units
- You may use a calculator
- Use the periodic table provided
- Marks available for each question are indicated in brackets
- Total marks for this paper = 100

Period \ Group	1	2										3	4	5	6	7	8
1	1 H Hydrogen 1																4 He Helium 2
2	7 Li Lithium 3	9 Be Berylium 4										11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
3	23 Na Sodium 11	24 Mg Magnesium 12										27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
4	39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
5	85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	(99) Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
6	133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
7	223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key

Relative atomic mass
Symbol
Name
Atomic number

Q1. The diagram represents an atom of an element.



(a) (i) What is the particle labelled X?

(1)

- □ **A** an electron
- □ **B** an ion
- □ **C** a proton
- □ **D** a neutron

(ii) What is the mass number of this atom?

(1)

- □ **A** 4
- □ **B** 5
- □ **C** 9
- □ **D** 13

(iii) Name the element that contains these atoms.

(1)

.....

(b) Hydrogen has three isotopes.

State, in terms of subatomic particles, one way in which these isotopes are the same and one way in which they are different.

(2)

same .....

.....

different .....

.....

(Total for question = 5 marks)

Q2. This question is about hydrogen (H_2) and water.

(a) Hydrogen is a gas at room temperature. It exists as simple molecules.

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

(1)

(ii) Explain why hydrogen has a very low boiling point.

(2)

.....

.....

.....

.....

(b) The symbols for the three isotopes of hydrogen are

^{1}H ^{2}H ^{3}H

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

(2)

.....

.....

.....

.....

(ii) Complete the table to show the number of protons, neutrons and electrons in each of the three isotopes of hydrogen.

(3)

	Isotope		
	^{1}H	^{2}H	^{3}H
number of protons			
number of neutrons			
number of electrons			

(c) When hydrogen burns in oxygen, heat energy is transferred to the surroundings.

(i) State the name given to a reaction in which heat energy is transferred to the surroundings.

(1)

.....

(ii) Write a chemical equation to represent the reaction that takes place when hydrogen burns in oxygen.

(2)

.....

(iii) Describe a chemical test to show that the product is water.

(2)

.....

.....

.....

.....

(iv) Describe a physical test to show that the product is pure water.

(2)

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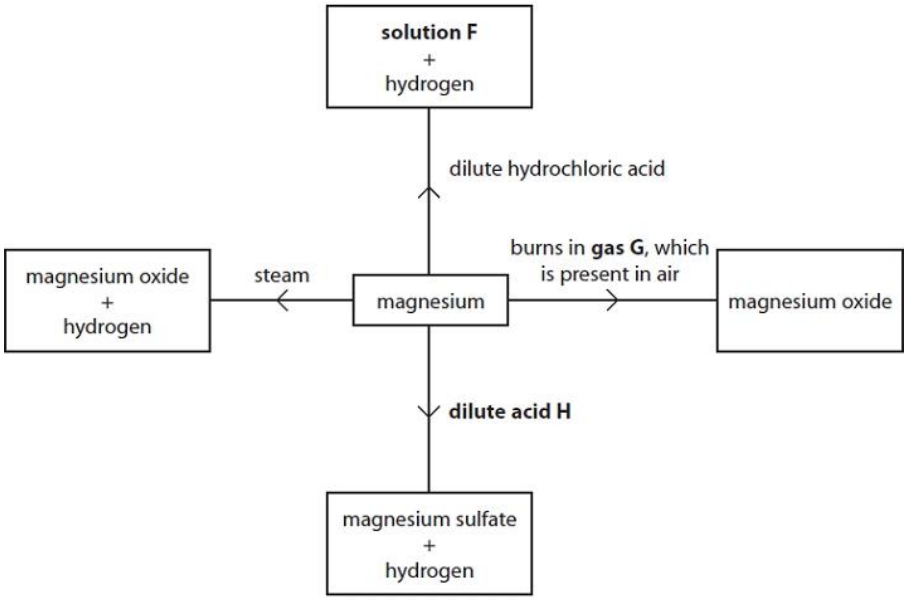
(Total for question = 15 marks)

Q3. The diagram shows some of the reactions of magnesium.



(a) Complete the table to give the identity of substances F, G and H.

(3)

Substance	Identity
solution F	
gas G	
dilute acid H	

(b) Write a chemical equation for the reaction between magnesium and steam.

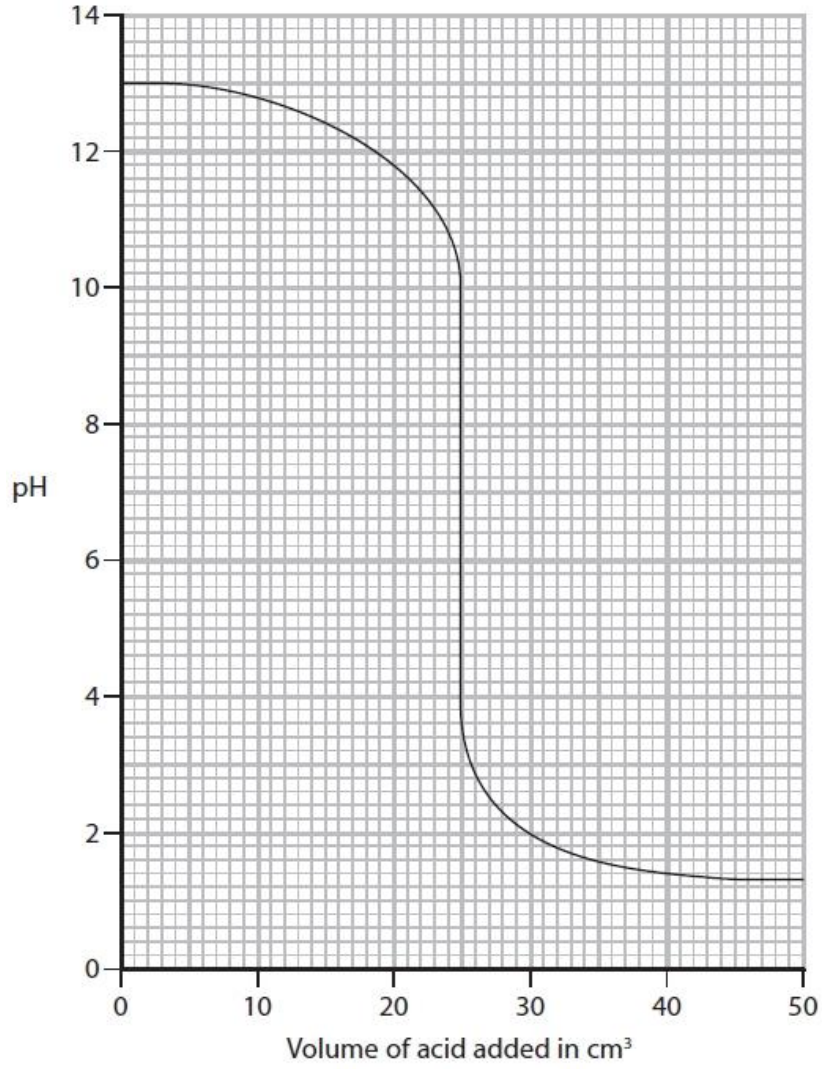
(1)

.....

(Total for question = 4 marks)

Q4. A total volume of 50 cm^3 of hydrochloric acid is added gradually to 50 cm^3 of sodium hydroxide solution containing some universal indicator.

The graph shows how the pH of the solution changes as the acid is added.



(a) Use the graph to answer these questions.

(i) What is the pH of the sodium hydroxide solution before any acid is added?

(1)

.....

(ii) What is the pH of the solution after 40 cm^3 of acid is added?

(1)

.....

(iii) What volume of acid is needed to completely neutralise the sodium hydroxide?

(1)

.....

(b) The table shows the colour of universal indicator at different pH values.

pH	0–2	3–4	5–6	7	8–9	10–12	13–14
Colour	red	orange	yellow	green	blue	indigo	violet

Complete the table below to show the colour of the solution when the volume of hydrochloric acid added is 20 cm^3 and when the volume added is 35 cm^3.

(2)

Volume of hydrochloric acid added in cm^3	Colour of solution
20	
35	

(c) Write a chemical equation for the reaction between sodium hydroxide and hydrochloric acid.

(1)

.....

(Total for question = 6 marks)

Q5. Choose the name of a substance from the box to answer parts (a) to (e).

Each name may be used once, more than once or not at all.

ammonia	chlorine	haematite	iron	sodium hydroxide

Give the name of

(a) a solid that conducts electricity.

(1)

.....

(b) a metal ore.

(1)

.....

(c) a substance formed in the Haber process.

(1)

.....

(d) a substance used to make soap.

(1)

.....

(e) a substance used to make fertilisers.

(1)

.....

(Total for question = 5 marks)

Q6. (a) Explain what is meant by the term **isomerism.**

(2)

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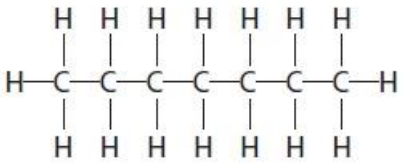
.....

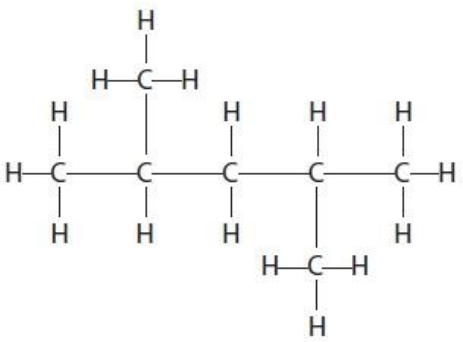
.....

(b) The displayed formula of heptane (C_7H_{16}) is

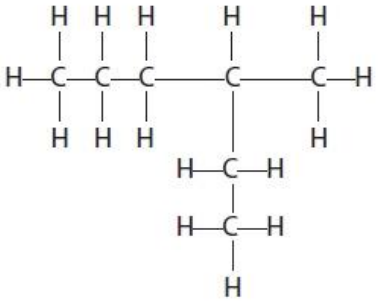


Which one of the displayed formulae below does **not** represent an isomer of heptane?
Place a cross (⊠) in the box to indicate your answer.

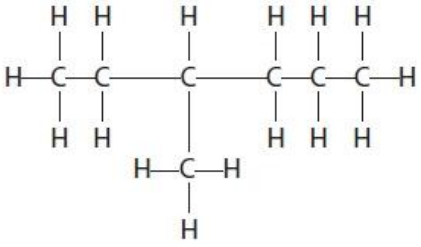
(1)



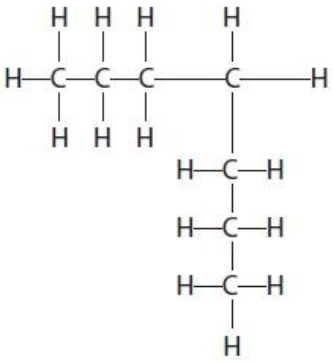
A ☐



B ☐



C ☐



D ☐

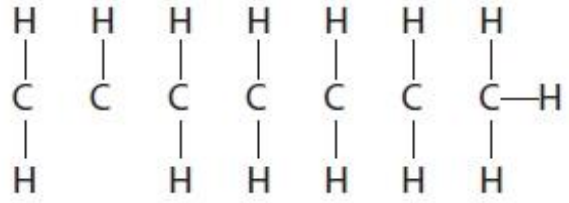
(c) Heptane belongs to a homologous series of compounds called alkanes.
The general formula of the alkanes is C_nH_{2n+2}
(i) Heptene belongs to a homologous series of compounds called alkenes.
Give the general formula of the alkenes.

(1)

.....

(ii) Complete the following diagram to show the structural formula of heptene (C_7H_{14}) by inserting lines to represent the covalent bonds between the carbon atoms.

(2)



(d) When heptene is added to bromine water, and the mixture is shaken, a reaction occurs.

State the type of reaction and give the colour of the bromine water before and after the reaction with heptene.

(3)

Type of reaction

.....

Colour before

.....

Colour after

.....

(e) Explain, in terms of the bonds present, why heptane is described as saturated and heptene as unsaturated.

(2)

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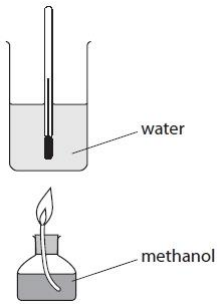
(Total for Question = 11 marks)

Q7. A student uses this apparatus to find the increase in temperature of water when methanol, CH_3OH, is burned.



(a) There are several reasons why the increase in temperature is less than expected.

(i) One reason is the incomplete combustion of methanol to form only carbon monoxide and water.

Write the chemical equation for this incomplete combustion.

(2)

.....

(ii) State another reason why the increase in temperature is less than expected.

(1)

.....

.....

(b) The student records these results.

mass of burner and methanol before combustion	84.7 g
mass of burner and methanol after combustion	83.2 g
mass of water	125 g
temperature of water at start	22 °C
temperature of water at end	58 °C

(i) Calculate the heat energy change (Q), in joules, in this experiment using the expression

$$Q = m \times 4.2 \times \Delta T$$

where m is the mass of water in grams and ΔT represents the increase in temperature.

(2)

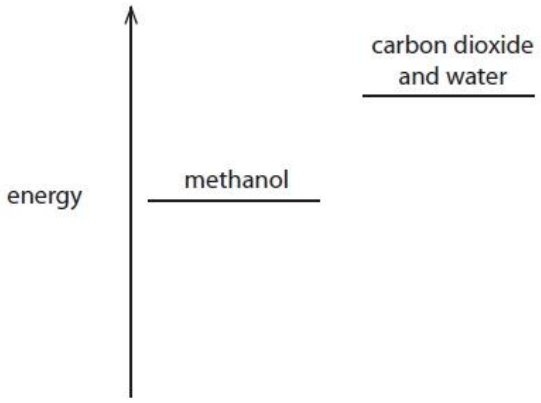
Q = ... J

(ii) The relative molecular mass of methanol is 32
Use this information and your value for *Q* to calculate the molar enthalpy change, Δ*H*, for the combustion of methanol.
Give your answer in kJ/mol.

(4)

Δ*H* = ... kJ/mol

(iii) The student draws an energy level diagram for the complete combustion of methanol.



Identify the two mistakes in his diagram.

(2)

1 .....

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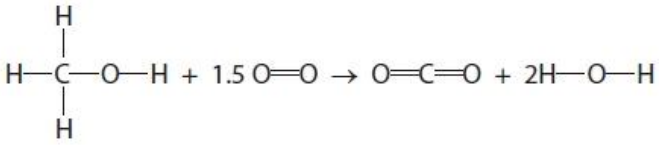
2 .....

.....

(c) The student is given this table of average (mean) bond energies.

Bond	C—H	C—O	O—H	O═O	C═O
Average bond energy in kJ/mol	412	360	463	496	743

The equation for the complete combustion of methanol is



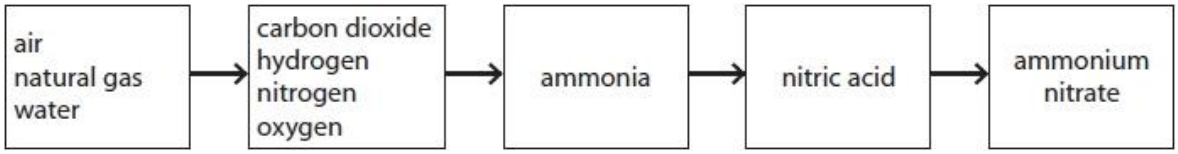
Use this equation and the information in the table to calculate another value for the molar enthalpy change, Δ*H*, for the combustion of methanol.

(4)

Δ*H* = ... kJ/mol

(Total for question = 15 marks)

Q8. The flow diagram shows how a fertiliser is manufactured from raw materials.



The hydrogen needed is formed in two reactions.

(a) Reaction 1 occurs between steam and methane in natural gas.

Balance the equation for this reaction.

(1)

..... CH_4 + ... H_2O → ..... CO + ... H_2

(b) The equation for reaction 2 is

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g) \qquad \Delta H = -41 \text{ kJ/mol}$$

(i) Assuming that this reaction reaches equilibrium, explain what happens to the yield of hydrogen if the reaction is carried out at a higher pressure but at the same temperature.

(2)

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.....

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.....

(ii) Assuming that this reaction reaches equilibrium, explain what happens to the yield of hydrogen if the reaction is carried out at a higher temperature but at the same pressure.

(2)

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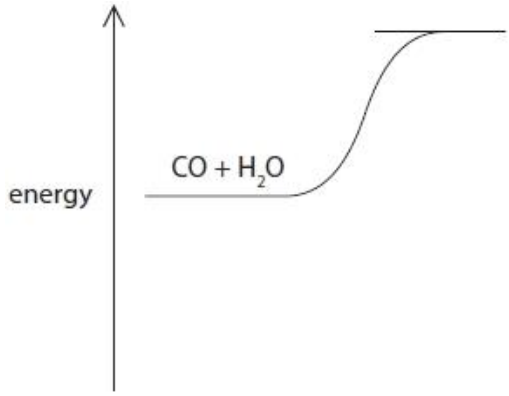
(c) Reaction 2 can be represented on an energy profile.



(i) Complete the profile by showing the products of the reaction and the enthalpy change for the reaction.

(2)

(ii) Reaction 2 is carried out using an iron oxide catalyst.
State the effect, if any, of using a catalyst on the enthalpy change for the reaction.

(1)

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.....

(iii) Explain how a catalyst increases the rate of a reaction.

(2)

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(d) The equations for some other reactions used in the manufacture of ammonium nitrate are

reaction 3 $N_2 + 3H_2 \rightleftharpoons 2NH_3$

reaction 4 $4NH_3 + 5O_2 \rightleftharpoons 4NO + 6H_2O$

reaction 5 $2NO_2 \rightleftharpoons N_2O_4$

reaction 6 $NH_3 + HNO_3 \rightarrow NH_4NO_3$

Explain which two of these are redox reactions.

(2)

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.....

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.....

(e) The manufacturer produces a batch of 34 kg of ammonia.

Calculate the maximum mass of ammonium nitrate that can be made from this mass of ammonia, using reaction 6 in part (d).
Give a unit for your answer.

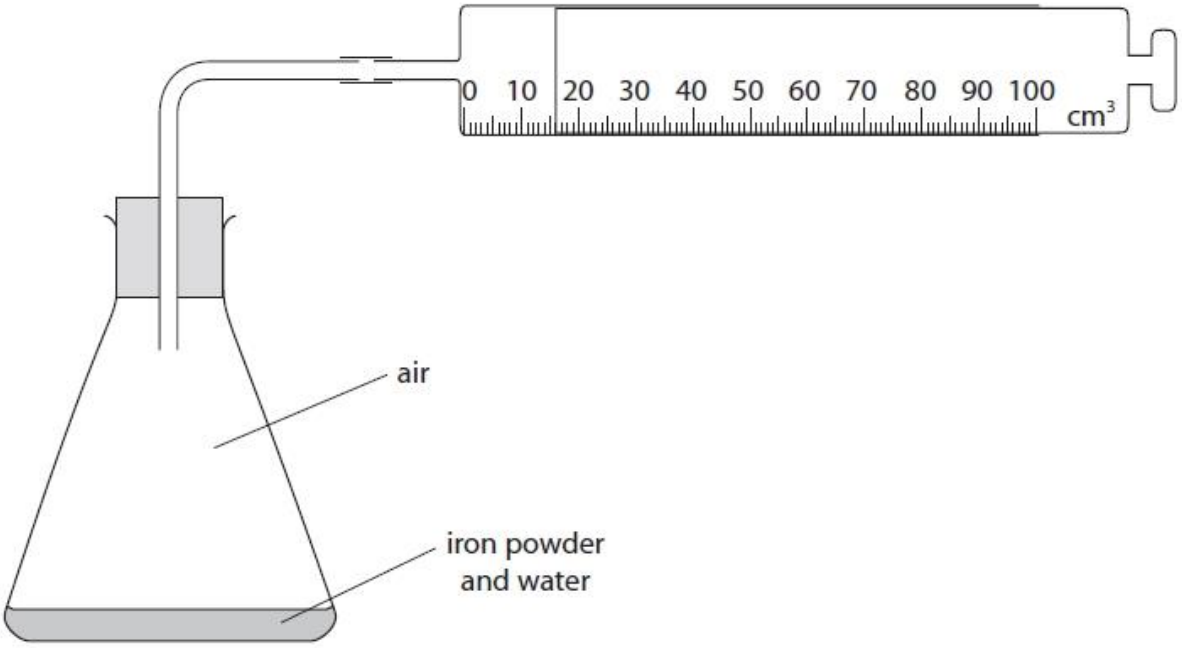
(3)

maximum mass of ammonium nitrate = ... unit ..... unit

(Total for question = 15 marks)

Q9. A student uses the reaction between iron and oxygen in an experiment to find the percentage by volume of oxygen in air.

The diagram shows his apparatus.



(a) State the advantage of using iron powder rather than pieces of iron.

(1)

.....

.....

(b) Why is it necessary for the student to mix the iron powder with water?

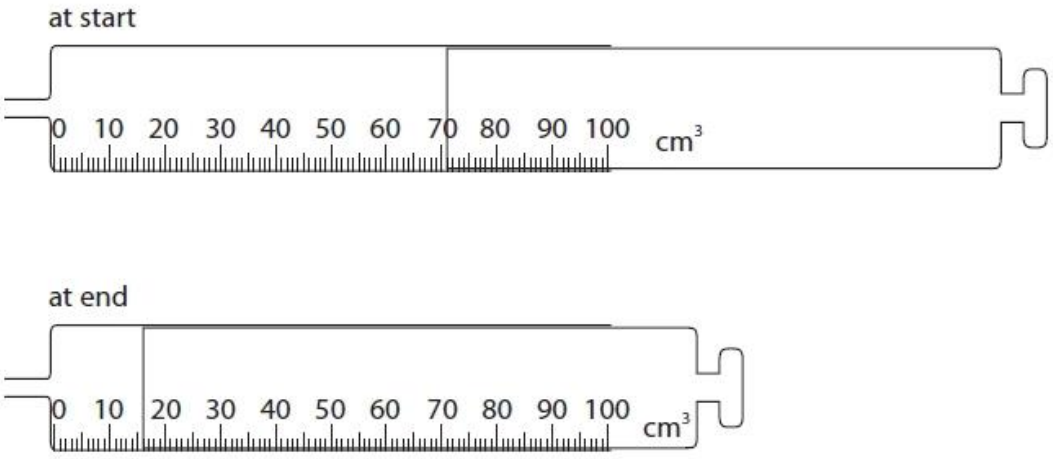
(1)

.....

.....

(c) The student records the reading on the syringe at the start of the experiment.

He then records the reading every day until there is no further change.
The diagram shows the syringe at the start and at the end of the experiment.



Use the readings to complete the table, entering all values to the nearest 1 cm^3.

(3)

volume reading at start in cm^3	
volume reading at end in cm^3	
change in volume in cm^3	

(d) The student repeats the experiment but obtains a much smaller change in volume.

Which of these could be a reason for the smaller change in volume?

(1)

- □ **A** he uses 10 cm^3 of water instead of 5 cm^3
- □ **B** he leaves the apparatus for a longer time
- □ **C** he leaves the apparatus in a warmer place
- □ **D** he uses a smaller mass of iron powder

(e) During another experiment, the student writes down these values.

volume of air in conical flask and glass tube	250 cm^3
syringe reading at start	90
syringe reading at end	20
volume of oxygen reacting	70 cm^3

The student incorrectly calculates the percentage by volume of oxygen in air.
This is his working.

$$\frac{70 \times 100}{90} = 78\%$$

(i) Identify the mistake in his working.

(1)

.....

.....

(ii) Use values from the table to correctly calculate the percentage by volume of oxygen in air.

(2)

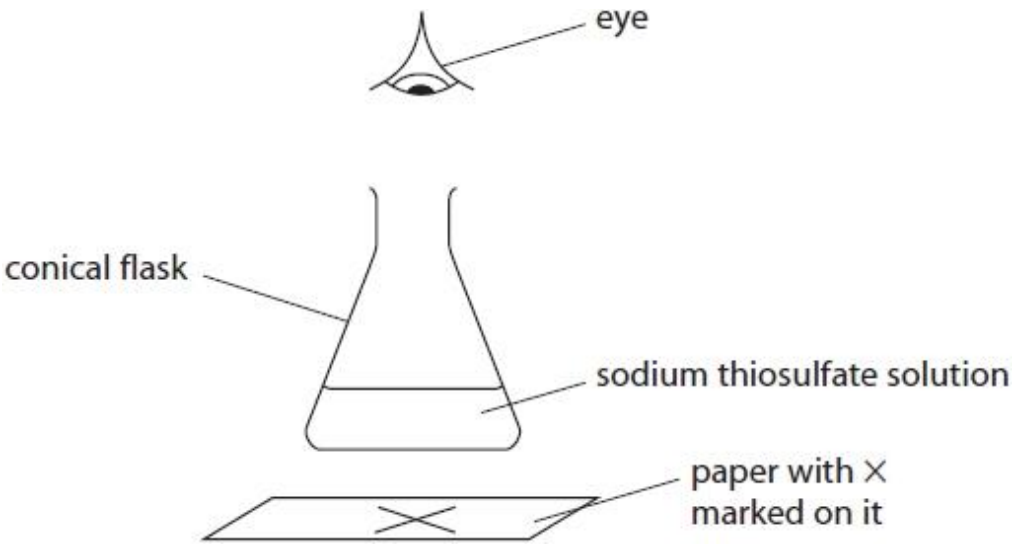
percentage = ... %

(Total for question = 9 marks)

Q10. Sodium thiosulfate solution and dilute hydrochloric acid react together slowly to form a precipitate of sulfur. This precipitate eventually makes the mixture go cloudy.

A student uses this method.

- place 20 cm^3 of sodium thiosulfate solution and 20 cm^3 of water in a conical flask
- add 10 cm^3 of dilute hydrochloric acid to the flask
- place the flask on a piece of paper marked with a black ×
- time how long it takes before the × can no longer be seen



(a) The equation for the reaction is

$$Na_2S_2O_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + S(s) + SO_2(g)$$

Before starting her experiments, the student considers the risk to her of sulfur dioxide escaping from the flask. She uses this information.

concentration of sodium thiosulfate solution = 0.300 mol/dm^3
volume of sodium thiosulfate solution = 20 cm^3
volume of water = 20 cm^3
volume of hydrochloric acid = 10 cm^3

(i) Calculate the mass of sulfur dioxide formed in this experiment.
The hydrochloric acid is in excess.

(3)

mass of sulfur dioxide formed = ... g

(ii) The solubility of sulfur dioxide at room temperature is 100 g/dm^3.
Use this additional information to explain whether any sulfur dioxide gas escapes from the flask.

(2)

.....

.....

.....

.....

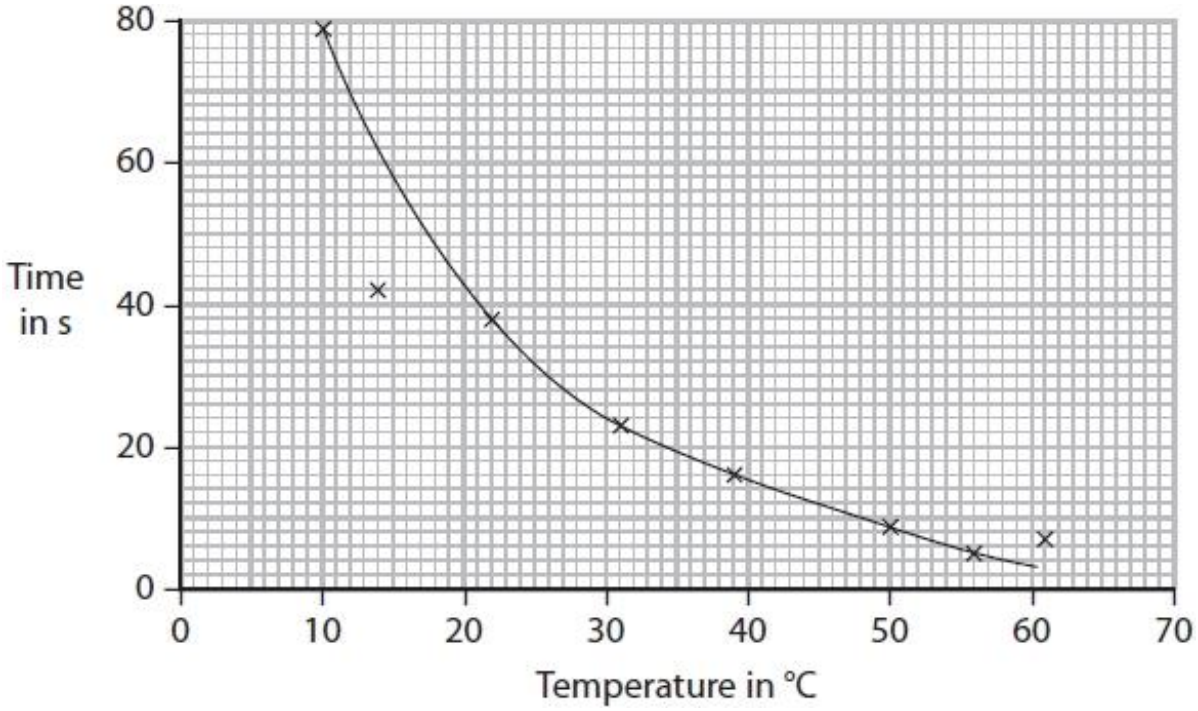
(b) At what point in the experiment should the student have started a timer?

(1)

.....

.....

(c) She repeats the experiment using the same volumes and concentrations of solutions, but at different temperatures. The graph shows her results.



(i) The result at (14, 42) is anomalous.
Explain one mistake the student may have made to cause this anomalous result.

(1)

.....

.....

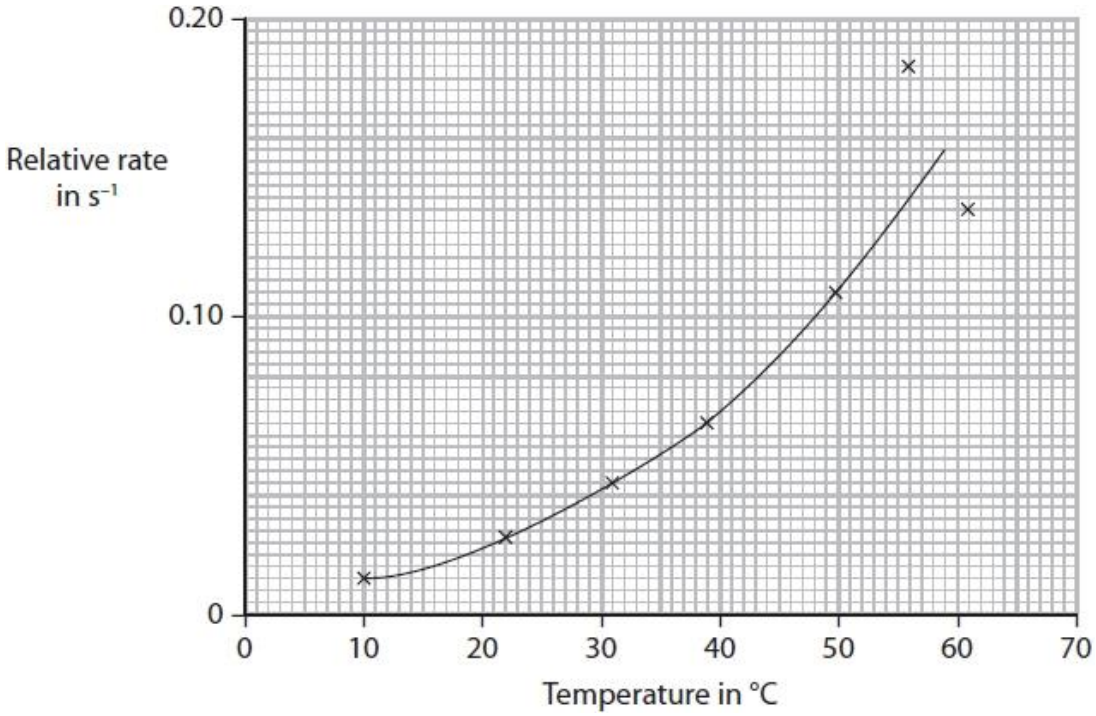
(ii) Use the graph to find the time taken for the × to be no longer seen at 35 °C.

(1)

.....

(d) The student repeats the experiments using nitric acid in place of hydrochloric acid.

She records the times for the × to no longer be seen, then uses the times to calculate the rate of reaction at each temperature.
The graph shows the results she plots.



(i) Suggest two reasons why the results are least accurate at higher temperatures.

(2)

1 .....

.....

2 .....

.....

(ii) The student wrote this explanation for the shape of the graph.

As the temperature increases, the rate of reaction increases. This is because there are more frequent collisions between particles of reactants.

Use the particle collision theory to explain another more important reason for the increase in reaction rate.

(2)

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.....

.....

.....

(e) Another student uses the same reaction to investigate the effect of changing the concentration of the sodium thiosulfate solution on the rate of reaction.

Give three variables that the student must control in this investigation to obtain valid results.

(3)

1 .....

.....

2 .....

.....

3 .....

.....

(Total for question = 15 marks)