Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1091/01 – LEGACY

S16-1091-01

CHEMISTRY – CH1

A.M. FRIDAY, 27 May 2016

1 hour 30 minutes

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1. to 6.	10	
Section B	7.	14	
	8.	16	
	9.	13	
	10.	15	
	11.	12	
	Total	80	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need a:
- calculator;
- copy of the **Periodic Table** supplied by WJEC.
  Refer to it for any **relative atomic masses** you require.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions in the spaces provided.
Section B Answer **all** questions in the spaces provided.

Candidates are advised to allocate their time appropriately between **Section A (10 marks)** and **Section B (70 marks)**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The *QWC* label alongside particular part-questions indicates those where the Quality of Written Communication is assessed.

If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

Examiner only

SECTION A

*Answer **all** questions in the spaces provided.*

1. Using the convention of arrows to represent electrons, complete the electronic structure of an atom of chromium. [1]

1s	2s	2p			3s	3p			3d					4s
↑↓	↑↓	↑↓	↑↓	↑↓										

2. State which **one** of the following statements is true. [1]

A The first ionisation energy of neon is greater than the first ionisation energy of helium.

B The first ionisation energy of sodium is less than the first ionisation energy of neon.

C The first ionisation energy values increase down Group 1.

D The second ionisation energy of sodium is less than the first ionisation energy of sodium.

....

3. The half-life of a radioactive isotope $^{24}_{x}Z$ is 15.0 hours. It decays by beta emission to a stable isotope of magnesium, $_{12}Mg$.

(a) Give the atomic number and symbol of this radioactive isotope. [1]

....

(b) After a period of 45.0 hours from the start of the decay, only 0.15 g of $^{24}_{x}Z$ remains.

Calculate the starting mass of the radioactive isotope $^{24}_{x}Z$. [2]

Starting mass = ... g

Examiner only

4. The mass spectrum of bromine trifluoride, $Br^{19}F_3$, shows two molecular ion peaks of equal intensity at m/z 136 and 138.

State what can be deduced about the relative isotopic masses of the bromine atoms present and their percentage abundances. [2]

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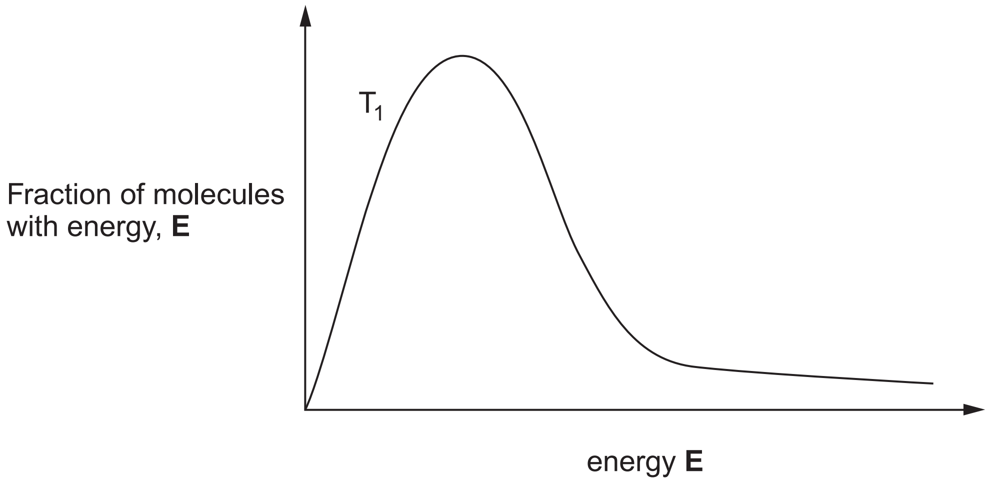
5. The graph shows the distribution of energies in a sample of gas at a certain temperature, T_1.



Sketch on the graph the curve obtained at a higher temperature, T_2. [1]

1091 010003

Turn over.

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6. The standard enthalpy change of formation, ΔH_f^θ, of phosphorus(V) chloride is –463 kJ mol^{-1}.

(a) State the standard conditions of temperature and pressure used, showing the units. [1]

Temperature ....

Pressure ....

(b) Calculate the heat evolved when 45.2 g of phosphorus(V) chloride (M_r 209) is produced from phosphorus and chlorine under standard conditions. [1]

Heat evolved = ... kJ

Total Section A [10]

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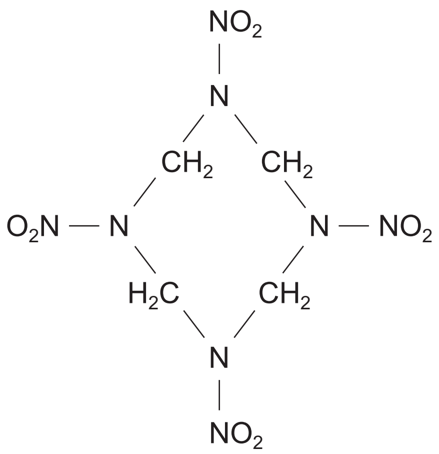
SECTION B

Answer **all** *questions in the spaces provided.*

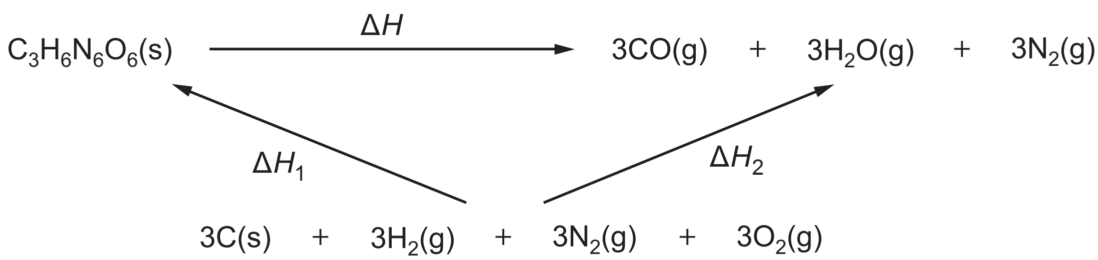
7. *(a)* The explosive HMX has the following structural formula. State its empirical formula. [1]



Empirical formula ....

(b) Another explosive, RDX, has the formula $C_3H_6N_6O_6$.

(i) Use the data table and the Hess cycle below to calculate the enthalpy of detonation, ΔH, of RDX. [3]



Compound	Enthalpy of formation ΔH_f / kJ mol^{-1}
RDX(s)	+62
CO(g)	−111
H_2O(g)	−242

ΔH = ... kJ mol^{-1}

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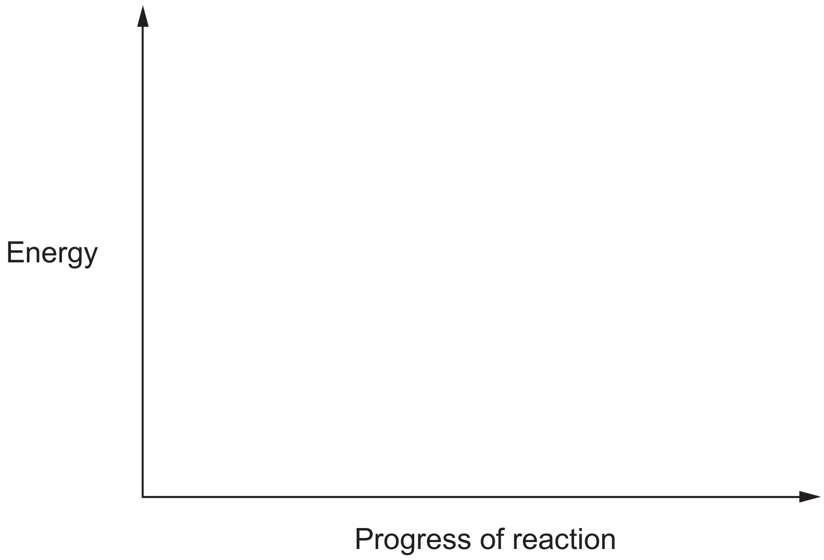
(ii) The result from *(b)*(i) can be used to help you sketch the reaction profile for the explosive detonation of RDX.

Draw this profile using the axes given below. Label your profile with reactants, products and the activation energy. [2]



(iii) The activation energy for the explosive detonation of RDX is 199 kJ mol^{-1} whereas the activation energy for the explosive detonation of mercury fulminate is 105 kJ mol^{-1}.

Define the term *activation energy* and hence comment on the relative stability of these two explosives. [2]

Examiner only

(c) The explosive Tetryl is made by adding concentrated nitric acid to N,N-dimethylphenylamine under suitable conditions. An equation for this is shown below.

$$C_6H_5N(CH_3)_2 \ + \ 4HNO_3 \longrightarrow \underset{\text{Tetryl}}{C_6H_2(NO_2)_3N(CH_3)(NO_2)} \ + \ CH_3OH \ + \ 3H_2O$$

(i) State why the atom economy for this reaction is not 100 %. [1]

....

....

(ii) Tetryl produced in this reaction needs further treatment. It can be purified by dissolving it in propanone and then adding water, or by recrystallisation using benzene as the solvent.

State any factor in the purification of Tetryl that **does not** fit with the principles of Green Chemistry. [1]

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(d) Many fireworks contain metal compounds that emit visible light. The colours given by barium and calcium compounds and their wavelengths are given in the table.

Metal	Colour	Wavelength / nm
barium	green	554
calcium	orange-red	616

(i) State which of these two colours has the higher energy, giving a reason for your answer. [1]

....

....

(ii) The colours seen are as a result of the emission of visible light. State how these colours are produced. [3]

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Total [14]

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8. *(a)* A student was given an aqueous solution of iodic(V) acid, HIO_3, and was asked to find its concentration by titration with sodium hydroxide solution.

$$NaOH + HIO_3 \longrightarrow NaIO_3 + H_2O$$

He rinsed the burette with water and then filled it with the iodic(V) acid solution. 25.0 cm^3 of sodium hydroxide solution of concentration 0.125 mol dm^{-3} were used for each titration against the aqueous iodic(V) acid. The following results were obtained.

Titration	1	2	3	4	5
Volume of iodic(V) acid solution used / cm^3	19.20	18.60	18.70	18.55	18.55

(i) Sodium hydroxide is described as a base. State what is meant by the term *base*. [1]

....

....

(ii) The teacher said that the result of titration 1 was too high. State **one** reason why a fault in the practical method could explain this result. [1]

....

....

(iii) Use the results from titrations 2 to 5 to calculate the mean volume of iodic(V) acid solution and hence the concentration of the acid in mol dm^{-3}. [3]

Concentration of iodic(V) acid = ... mol dm^{-3}

Examiner only

(iv) Iodic(V) acid is an expensive material to use and a student suggested that it would be more economical if only 10.00 cm^3 of sodium hydroxide solution were used for each titration.

Suggest **one** reason why this was not done in this experiment. [1]

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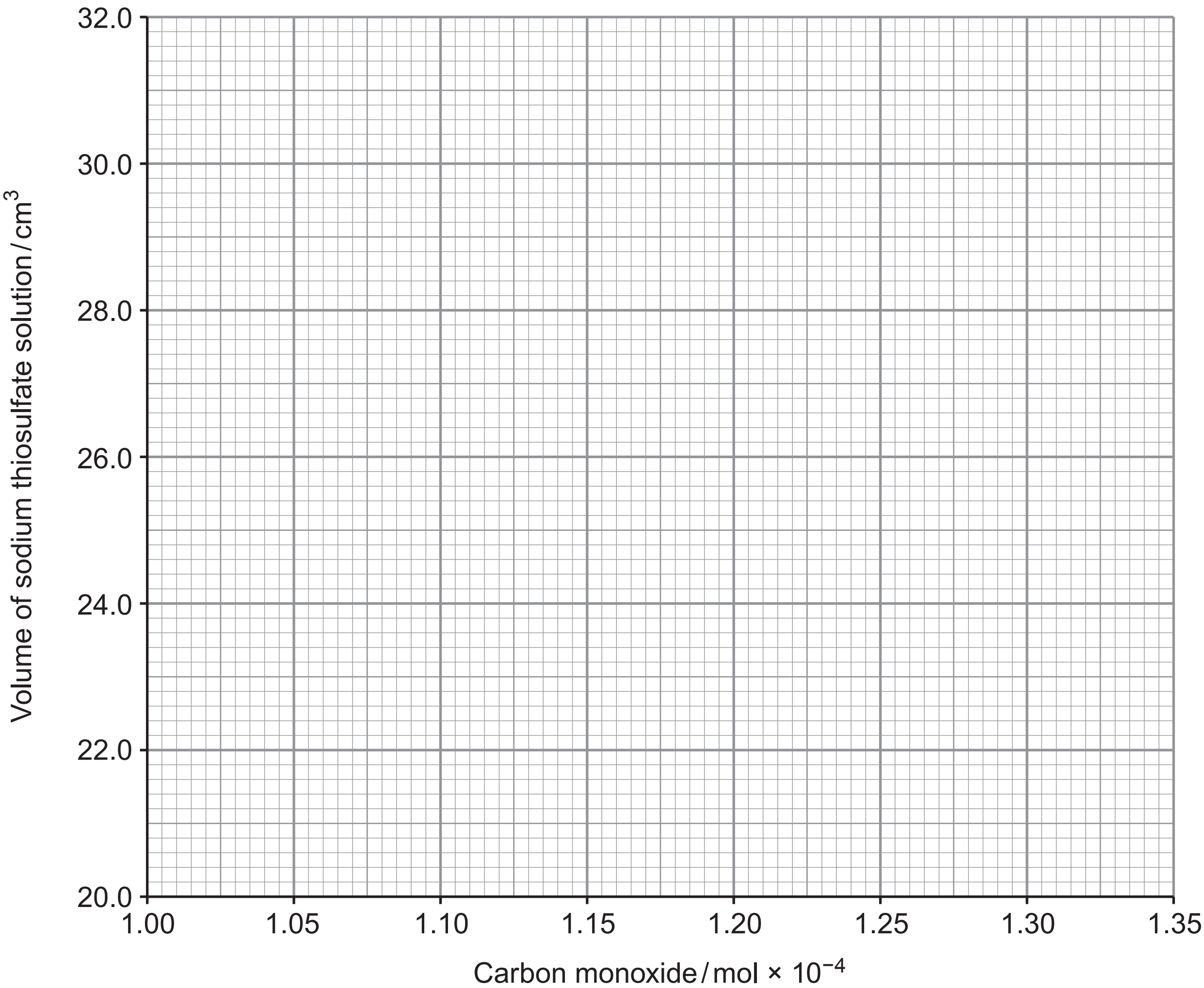
Examiner only

(b) The percentage by volume of carbon monoxide in a gas mixture can be found by reacting it with an iodine compound, and titrating with sodium thiosulfate solution, from which the number of moles of carbon monoxide present can be found.

Two results obtained by this method are shown below.

Volume of sodium thiosulfate solution / cm^3	23.5	30.2
Carbon monoxide / mol × 10^{-4}	1.05	1.30

(i) Plot these two points on the grid provided and then join them with a straight line. [1]



Examiner only

(ii) In an experiment the carbon monoxide in a gas mixture of volume 300 cm^3 gave a reading of 28.40 cm^3 of sodium thiosulfate solution.

Use your graph to find the number of moles of carbon monoxide present in the gas mixture and hence calculate the percentage by volume of carbon monoxide in the gas mixture. Give your answer to **three** significant figures. [3]
[1 mol of any gas has a volume of 24 000 cm^3 at the conditions used]

Percentage of carbon monoxide by volume = ... *%*

(c) Harmful gases from vehicle exhausts include carbon monoxide and nitrogen(II) oxide, NO. In a catalytic converter these two gases are converted to nitrogen and carbon dioxide by passing them over a mixture of platinum and rhodium metals.

Give the equation for this reaction. [1]

....

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Examiner only

(d) Catalysts are very important in many industrial processes.

Discuss how catalysts

- increase the rate of a reaction
- affect equilibrium reactions

[4]
QWC [1]

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Total [16]

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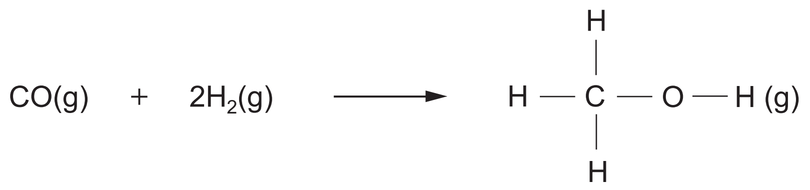
Examiner only

9. *(a)* Methanol, CH_3OH, is made from a mixture that contains carbon monoxide and hydrogen.



(i) Use the table of average bond enthalpies to calculate the enthalpy change for this reaction. [2]

Bond	Bond enthalpy / kJ mol^{-1}
C—O	336
C—H	413
H—H	436
O—H	464
C≡O in carbon monoxide	1077

Enthalpy change = ... kJ mol^{-1}

(ii) State why the calculated value for the enthalpy change of reaction may not be the same as the literature value. [1]

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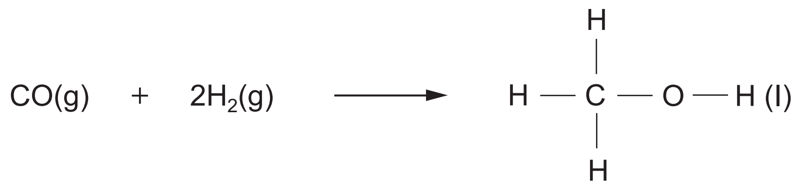
....

(iii) The literature value of the enthalpy change for the reaction



is more exothermic than the literature value for the reaction shown opposite.

State why these two values are different, explaining your answer. [1]

(iv) The reaction to make methanol is in dynamic equilibrium.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

I. State what is meant by the term *dynamic equilibrium*. [1]

II. Use the equation above and your answer to (i) to suggest and explain the conditions of temperature and pressure that will give the greatest yield of methanol. [2]

Examiner only

(b) The equation for the reaction that represents the enthalpy change of combustion of methanol, ΔH_c , is shown below.

$$CH_3OH(l) \quad + \quad 1\tfrac{1}{2}O_2(g) \longrightarrow CO_2(g) \quad + \quad 2H_2O(l)$$

(i) Estimate the enthalpy change of combustion of methanol by using the following table, explaining how you obtained your answer. [2]

Name of alcohol	Number of carbon atoms in the alcohol	Enthalpy change of combustion / kJ mol^{-1}
butan-1-ol	4	−2678
pentan-1-ol	5	−3331
hexan-1-ol	6	−3984

....

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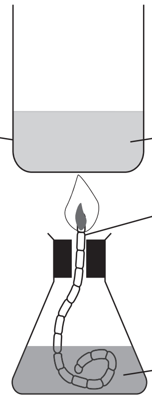
....

Enthalpy change of combustion = ... kJ mol^{-1}

Examiner only

(ii) Enthalpy changes of combustion can be measured directly. A student used the apparatus below to obtain the value for methanol.



The result obtained by this method is often lower than the accepted value.

Suggest **one** way in which the apparatus could be modified in order to obtain a result closer to the expected value, giving a reason for your answer. [2]

....

....

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(iii) In another experiment the enthalpy change of combustion of methanol was measured and found to be −680 kJ mol^{-1}.

Calculate the mass of methanol burned in this experiment if the energy released by burning the methanol was 18.7 kJ. [2]

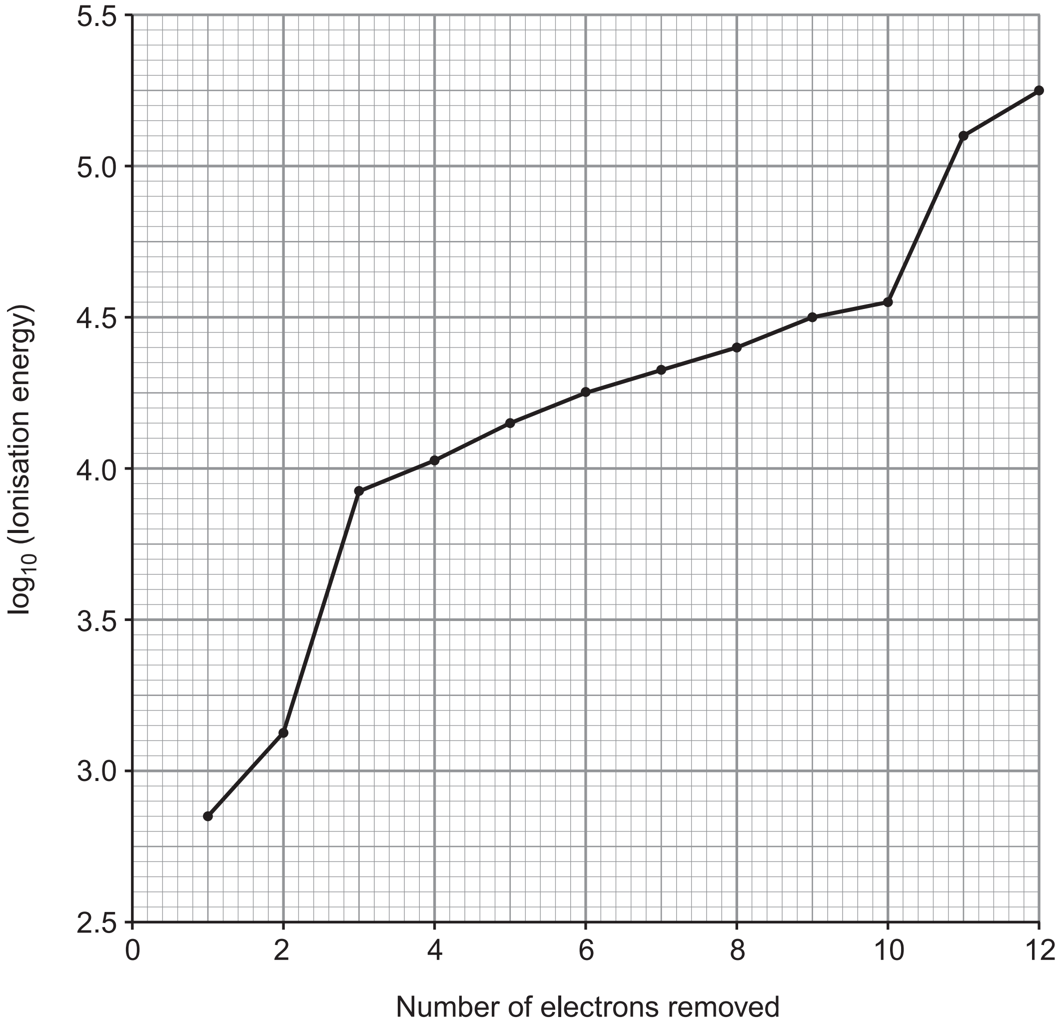
Mass of methanol = ... g

Total [13]

Turn over.

Examiner only

10. *(a)* The graph below shows the log of the successive ionisation energies for magnesium.



Examiner only

Using the electron configuration for magnesium discuss how and why the values for the ionisation energies change according to the number of electrons removed. [4]

QWC [1]

Examiner only

(b) Strontium, Sr, is another metal found in Group 2 of the Periodic Table. It reacts rapidly with cold water to produce a solution of the strong base strontium hydroxide, $Sr(OH)_2$, and hydrogen.

$$Sr + 2H_2O \longrightarrow Sr(OH)_2 + H_2$$

In an experiment 1.260 g of strontium gave 0.0140 mol of hydrogen gas.

(i) Use this information to calculate the relative atomic mass of strontium in this sample. [2]

Relative atomic mass of strontium = ...

(ii) A solution of strontium hydroxide can be used to obtain crystals of hydrated strontium hydroxide, $Sr(OH)_2.xH_2O$. On heating to 100 °C the water is lost giving anhydrous strontium hydroxide.

$$Sr(OH)_2.xH_2O(s) \longrightarrow Sr(OH)_2(s) + xH_2O(g)$$

A sample of hydrated strontium hydroxide of mass 11.95 g was heated and produced 5.47 g of anhydrous strontium hydroxide (M_r 121.62).

Calculate the value of x in $Sr(OH)_2.xH_2O$. [3]

x = ...

Examiner only

(iii) Use the information in the question to suggest another method that could be used to find the value of x in $Sr(OH)_2.xH_2O$ and how this method could be used to produce the value of x. [3]

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(c) A solution that cannot dissolve any more solute is called a saturated solution. A saturated solution of strontium chloride can be represented as an equilibrium mixture between the solid and its solution.

$$SrCl_2(s) \rightleftharpoons Sr^{2+}(aq) + 2Cl^-(aq)$$

When hydrochloric acid is added, the clear solution of strontium chloride becomes cloudy.

Use Le Chatelier's Principle to explain the appearance of this cloudiness. [2]

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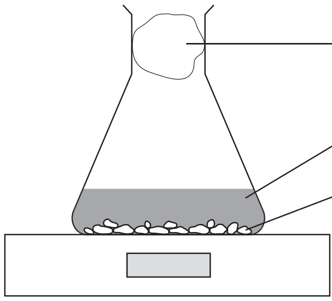
Total [15]

Examiner only

11. Magnesite is a mineral that consists largely of magnesium carbonate. A sample of crushed magnesite of mass 6.72 g and an excess of dilute hydrochloric acid of concentration 2 mol dm^{-3} were placed in a conical flask on a balance.



Carbon dioxide was given off during the reaction and the loss in mass was recorded at set intervals.

(a) Suggest why cotton wool was placed in the neck of the flask. [1]

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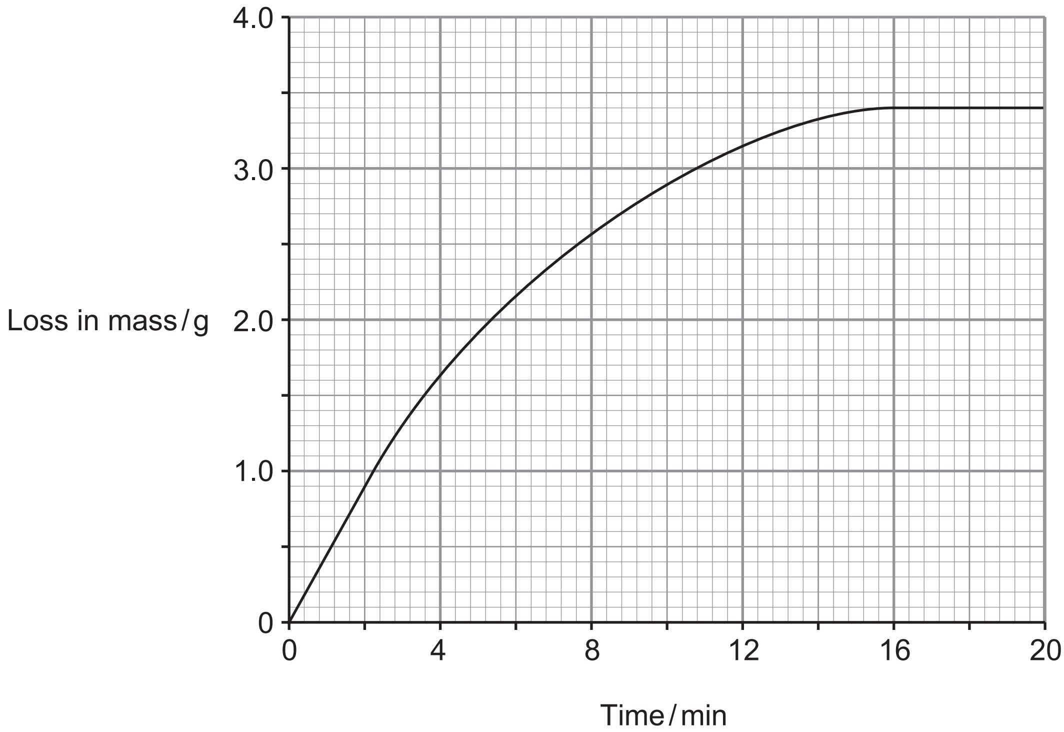
Examiner only

(b) The results from the experiment were plotted in a graph.



(i) Use the graph to find the time taken for half of the original mass of magnesite to react. [1]

Time = ... min

(ii) Use the graph to calculate the initial rate of the reaction, giving its unit. [2]

Rate = ...

Unit ....

Examiner only

(iii) Use collision theory to explain how the rate of the reaction changes during the reaction. You should consider **both** reactants in your answer. [3]
QWC [1]

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(iv) The experiment was repeated using the same mass of magnesite but in a lump form.

Sketch on the graph (previous page) the resulting line for this experiment. [2]

(c) In a further experiment an excess of magnesite was added to some hydrochloric acid. At the end of the reaction a neutral solution of magnesium chloride and some unreacted magnesite remained.

Outline how the pH of the mixture would change during this reaction, suggesting pH values where appropriate. [2]

....

....

....

Total [12]

Section B Total [70]

END OF PAPER

Examiner only

For continuation only.

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GCE AS/A level

1091/01-A – LEGACY

S16-1091-01A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

A.M. FRIDAY, 27 May 2016

THE PERIODIC TABLE

Key: A_r (relative atomic mass) / Symbol / Name / Z (atomic number)

s Block: Groups 1–2; d Block: between Groups 2 and 3; p Block: Groups 3–0; f Block: Lanthanoid and Actinoid elements

Period	Group 1	Group 2											Group 3	Group 4	Group 5	Group 6	Group 7	Group 0
1	1.01 H Hydrogen 1																	4.00 He Helium 2
2	6.94 Li Lithium 3	9.01 Be Beryllium 4											10.8 B Boron 5	12.0 C Carbon 6	14.0 N Nitrogen 7	16.0 O Oxygen 8	19.0 F Fluorine 9	20.2 Ne Neon 10
3	23.0 Na Sodium 11	24.3 Mg Magnesium 12											27.0 Al Aluminium 13	28.1 Si Silicon 14	31.0 P Phosphorus 15	32.1 S Sulfur 16	35.5 Cl Chlorine 17	40.0 Ar Argon 18
4	39.1 K Potassium 19	40.1 Ca Calcium 20	45.0 Sc Scandium 21	47.9 Ti Titanium 22	50.9 V Vanadium 23	52.0 Cr Chromium 24	54.9 Mn Manganese 25	55.8 Fe Iron 26	58.9 Co Cobalt 27	58.7 Ni Nickel 28	63.5 Cu Copper 29	65.4 Zn Zinc 30	69.7 Ga Gallium 31	72.6 Ge Germanium 32	74.9 As Arsenic 33	79.0 Se Selenium 34	79.9 Br Bromine 35	83.8 Kr Krypton 36
5	85.5 Rb Rubidium 37	87.6 Sr Strontium 38	88.9 Y Yttrium 39	91.2 Zr Zirconium 40	92.9 Nb Niobium 41	95.9 Mo Molybdenum 42	98.9 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	179 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															

f Block

▸ Lanthanoid elements	140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	(147) Pm Promethium 61	150 Sm Samarium 62	(153) Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
▸▸ Actinoid elements	232 Th Thorium 90	(231) Pa Protactinium 91	238 U Uranium 92	(237) Np Neptunium 93	(242) Pu Plutonium 94	(243) Am Americium 95	(247) Cm Curium 96	(245) Bk Berkelium 97	(251) Cf Californium 98	(254) Es Einsteinium 99	(253) Fm Fermium 100	(256) Md Mendelevium 101	(254) No Nobelium 102	(257) Lr Lawrencium 103