PMT

Surname	Centre Number	Candidate Number
Other Names		2

WJEC CBAC

GCE AS/A level

1091/01

CHEMISTRY – CH1

A.M. THURSDAY, 10 January 2013

1½ hours

FOR EXAMINER'S USE ONLY		
Section	Question	Mark
A	1-6	
B	7	
	8	
	9	
	10	
	11	
TOTAL MARK		

1091 010001

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. Do not use gel pen or correction fluid.

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.

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Examiner only

SECTION A

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

1. The mass number of an isotope of gallium is 70.

State the number of neutrons in an atom of this isotope. .... [1]

2. Write the letter which represents the correct equation for the **second** ionisation energy of gallium in the box below. [1]

A $Ga(g) + 2e^- \longrightarrow Ga^{2-}(g)$

B $Ga(g) \longrightarrow Ga^{2-}(g) + 2e^-$

C $Ga^+(g) \longrightarrow Ga^{2+}(g) + e^-$

D $Ga^{2+}(g) + 2e^- \longrightarrow Ga(g)$

3. An enriched isotopic mixture of lithium contains ^6Li 12.0% and ^7Li 88.0% by mass. Showing your working, calculate the relative atomic mass of this sample of lithium. Give your answer to **three** significant figures. [2]

Relative atomic mass = ...

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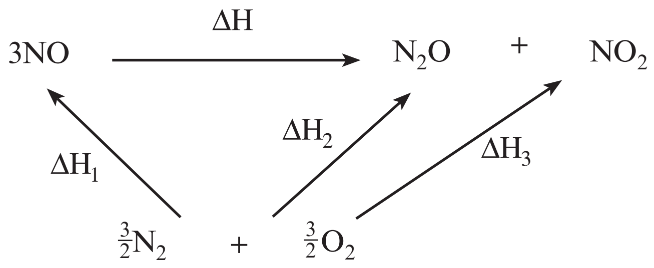
4. The energy cycle for a decomposition of nitrogen(II) oxide is shown below.



(a) Complete the equation to show ΔH in terms of ΔH_1, ΔH_2 and ΔH_3. [1]

ΔH = ...

(b) Write the chemical equation for the standard molar enthalpy change of formation of gaseous nitrogen(II) oxide, NO. [1]

....

5. Carbon oxide sulfide, COS, is obtained by heating together carbon monoxide and gaseous sulfur.

$$2CO(g) + S_2(g) \rightleftharpoons 2COS(g)$$

State and explain any change that occurs when more carbon monoxide is added to the equilibrium mixture. [2]

....

....

....

....

....

....

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0 3

6. An oxide of titanium contains 60% of titanium by mass. Calculate the empirical formula of this oxide of titanium. [2]

[A_r (Ti) = 48]

Empirical formula ....

Section A Total [10]

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SECTION B

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

7. *(a)* In 2011 a man was detained at Moscow Airport when he tried to smuggle samples containing a radioactive isotope of sodium, ^{22}Na, onto an aircraft.

(i) This isotope is made from an aluminium isotope by loss of an α-particle.

State what is meant by an α-*particle*. [1]

....

(ii) ^{22}Na decays by the loss of a positron. This may occur by the breakdown of a proton into a neutron and a positron, giving the product, ^{b}X.

Deduce the mass number (b) and the chemical symbol (X) of this product. [2]

b ....

X ....

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(iii) The half-life of the isotope ^{22}Na is 2.6 years. The mass of a sample of this isotope is 48 mg.

Calculate the time taken for the mass of ^{22}Na to fall to 3 mg. [1]

Time taken = ... years

(b) The visible emission spectrum of sodium shows a strong yellow-orange line at a wavelength of 589 nm and a weaker green line at 569 nm.

Complete the sentences below by using the words **higher** or **lower** as appropriate. [1]

The frequency of the green line at 569 nm is .... than the frequency of the yellow-orange line at 589 nm. Another line is seen at 424 nm. This is caused by an electronic transition of .... energy than the line at 569 nm.

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(c) Trona is a naturally-occurring 'sodium carbonate' mineral. It has the formula $Na_2CO_3.NaHCO_3.2H_2O$.

(i) Show that the relative molecular mass of trona is 226. [1]

(ii) On heating, trona loses water and carbon dioxide giving sodium carbonate.

$$2[Na_2CO_3.NaHCO_3.2H_2O](s) \longrightarrow 3Na_2CO_3(s) + CO_2(g) + 5H_2O(l)$$

Calculate the atom economy of this reaction, assuming that sodium carbonate is the only required product. [2]

Atom economy = ... %

(iii) The above reaction is used commercially to obtain sodium carbonate.

Suggest **one** environmental disadvantage of this reaction as indicated by the equation, and state what could be done to overcome this problem. [2]

....

....

....

....

Examiner only

(d) When sodium carbonate is added to water, some of the carbonate ions react with the water to give an alkaline solution.

$$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^{-}(aq) + OH^{-}(aq)$$

(i) Explain why this reaction is considered to be an acid-base reaction. [2]

....

....

....

....

(ii) The pH of a sodium carbonate solution is 11.4.
How would you explain the meaning of the pH scale to a member of the public? [3]

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....

Total [15]

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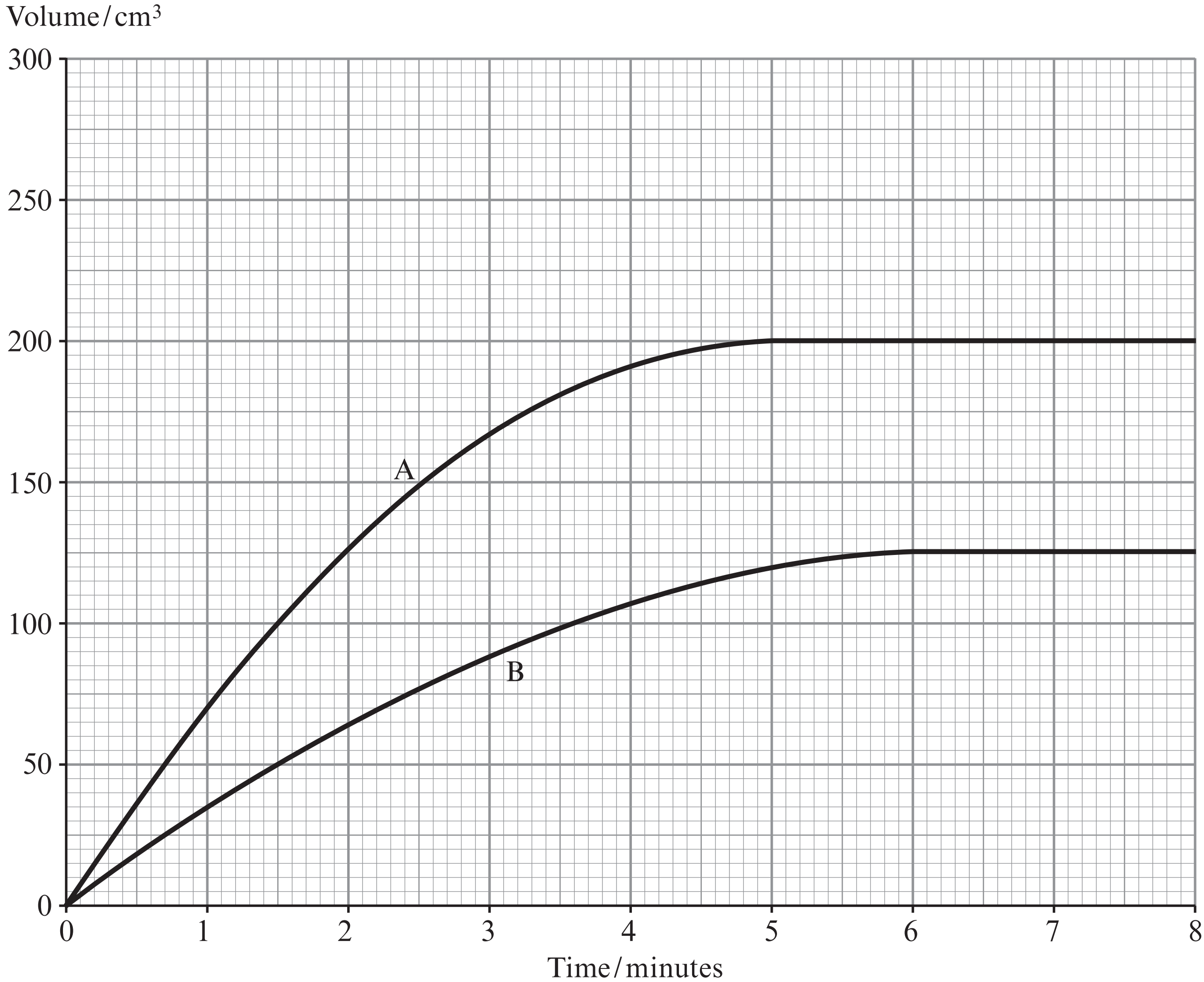
8. Dolomite, $MgCO_3.CaCO_3$, is a mineral containing magnesium carbonate and calcium carbonate.

(a) Some students were asked to react samples of dolomite, each of mass 0.50 g, with an excess of dilute hydrochloric acid and to follow the rate of the reaction by measuring the volume of carbon dioxide evolved at suitable time intervals.

(i) Line **A** on the graph shows Natalie's results. Her teacher said that this was correct. David's line is labelled **B**. Although his line represents his results, the teacher said that he must have done something wrong during the experiment to obtain these results.



Suggest and explain **two** things that he might have done wrongly to obtain these results. [2]

1. ....

....

2. ....

....

Examiner only

(ii) Explain why, in Natalie's experiment, 0.25 g of the dolomite has reacted in 1.5 minutes but the remaining 0.25 g has taken a further 3.5 minutes to react. [2]

....

....

....

(iii) Emma asked what the volume of carbon dioxide collected from the samples would be if the temperature rose from 298 K to 323 K.
The teacher explained that, if the pressure remained the same, volume V (in cm^3) and temperature T (in Kelvin) were linked by the equation

$$V = k \times T \qquad \text{where k is constant.}$$

The volume of carbon dioxide evolved at 298 K is 130 cm^3. By finding the value of k, or by other means, calculate the volume of this carbon dioxide when its temperature is raised to 323 K. [2]

Volume of carbon dioxide = ... cm^3

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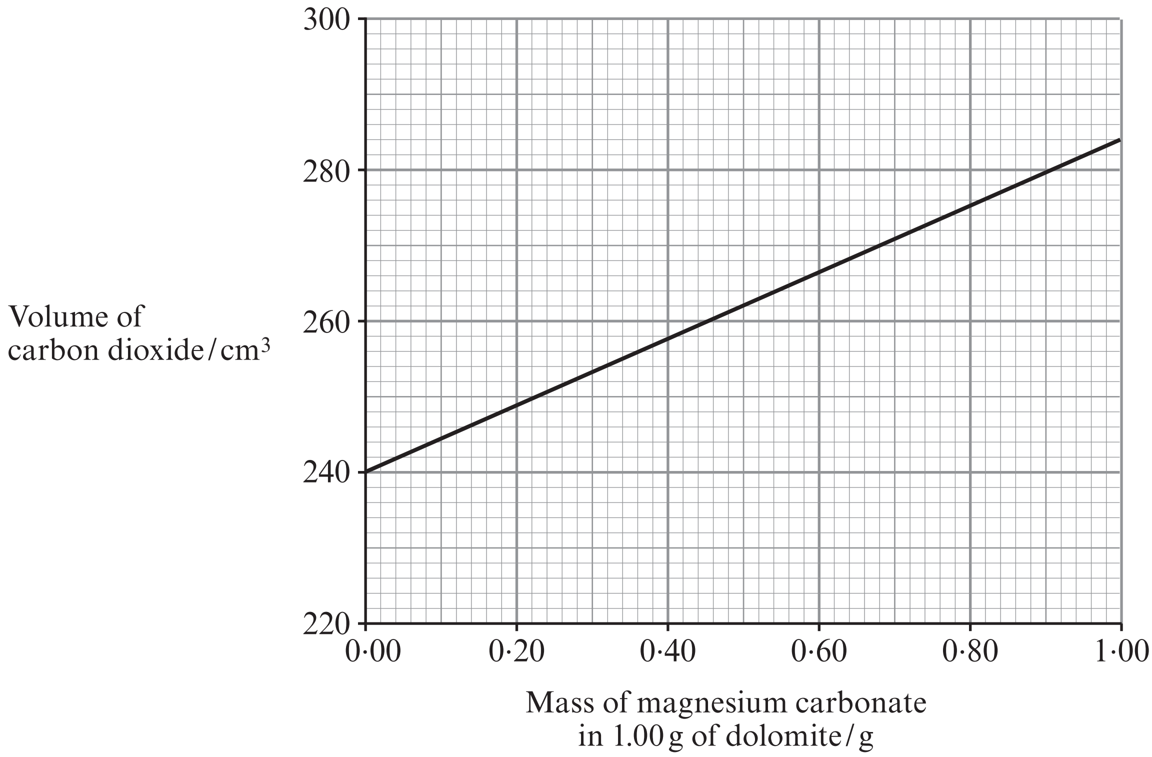
(b) In another experiment 0.623 g of dolomite reacted with an excess of dilute hydrochloric acid. The total volume of carbon dioxide evolved was 162 cm^3.

(i) Calculate the total volume of carbon dioxide that would be evolved if a sample of dolomite of mass 1.00 g was used under the same conditions. [1]

Volume of carbon dioxide = ... cm^3

(ii) Use the graph below to find the mass of magnesium carbonate present in this 1.00 g sample of dolomite. [1]

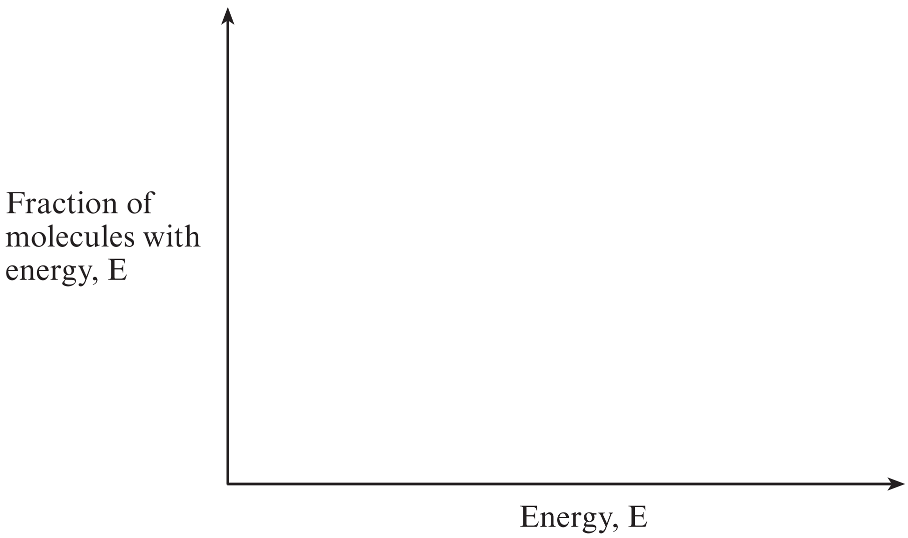


Mass of magnesium carbonate = ... g

Examiner only

(c) The rate of the reaction between dolomite and hydrochloric acid increases by a large amount if the temperature is increased.

Complete the following energy distribution curve diagram by drawing two lines that show the distribution of energies at two different temperatures.
Label the line at lower temperature T_1 and the line at higher temperature T_2.
Use the diagram to help you explain why the rate increases as the temperature increases. [3]
QWC [1]



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(d) Briefly outline a different method of following the rate of the reaction between dolomite and hydrochloric acid. [2]

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Total [14]

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Examiner only

9. *(a)* Nitrogen(I) oxide is a colourless gas that reacts with hydrogen to give nitrogen and water.

$$N_2O(g) + H_2(g) \longrightarrow N_2(g) + H_2O(l) \qquad \Delta H = -368\,kJ\,mol^{-1}$$

(i) State why the standard enthalpy of formation of both hydrogen and nitrogen gases is $0\,kJ\,mol^{-1}$. [1]

....

....

(ii) Calculate the standard enthalpy of formation of nitrogen(I) oxide in $kJ\,mol^{-1}$. (You should assume that the standard enthalpy of formation of water is $-286\,kJ\,mol^{-1}$) [2]

Standard enthalpy of formation = ... $kJ\,mol^{-1}$

(b) A new method for producing phenol, C_6H_5OH, is by reacting benzene, C_6H_6, with nitrogen(I) oxide at 400 °C in the presence of a suitable catalyst.

$$C_6H_6 + N_2O \longrightarrow C_6H_5OH + N_2 \qquad \Delta H = -286\,kJ\,mol^{-1}$$

(i) Sketch the energy profiles for the catalysed and uncatalysed reactions using the axes shown below.
Label your profiles as *catalysed* and *uncatalysed*. [2]

Energy

Extent of reaction

(ii) A pilot-scale plant used 156 kg of benzene ($M_r = 78$) to produce phenol ($M_r = 94$).

I Calculate the number of moles of benzene used. [1]

Moles of benzene = ... mol

II The yield of phenol was 95%. Using your answer to I and the equation below (or another suitable method), calculate the mass of phenol obtained. Show your working. [3]

$$C_6H_6 + N_2O \longrightarrow C_6H_5OH + N_2$$

Mass of phenol = ... kg

Examiner only

(iii) Study the short account below, which gives more detail about this process.

The process to make phenol is carried out in the gas phase and uses a solid zeolite catalyst. The operating temperature is around 400 °C.

$$C_6H_6 + N_2O \longrightarrow C_6H_5OH + N_2 \qquad \Delta H = -286\,kJ\,mol^{-1}$$

The reactants are the hydrocarbon benzene and nitrogen(I) oxide, which is a potent greenhouse gas. The nitrogen(I) oxide is obtained from another process, where it is produced as an undesirable side product.

Use the account and the equation to comment on the environmental and *Green Chemistry* advantages of this process. A reference to the yield is not required. [4]
QWC [1]

....

....

....

....

....

....

....

....

Total [14]

Examiner only

10. *(a)* Potassium hydroxide contains potassium ions, K^+.
Give the electron configuration of a potassium **atom** and use this to explain why most potassium compounds contain the potassium ion. [2]

....

....

....

(b) Michael was asked to make 250 cm^3 of a solution of potassium hydroxide and to record the maximum rise in temperature that occurred as it dissolved.
He measured 250 cm^3 of water in a glass beaker and then added 7.01 g (0.125 mol) of solid potassium hydroxide to this, with stirring.
He noticed that the temperature rose from 20.2 °C to a maximum of 25.0 °C.

(i) Calculate the molar enthalpy change of solution of potassium hydroxide by use of the formula

$$\Delta H = -\frac{mc\Delta T}{n}$$

where m = mass of the solvent in grams (assume 1 cm^3 has a mass of 1 g)
c = 4.2 $J\,g^{-1}\,°C^{-1}$
ΔT = change in temperature of the solution
n = number of moles of the solute
ΔH = molar enthalpy change of solution

You should show the **units** in your answer. [3]

ΔH = ...

(ii) Michael's measurements produced a value for the enthalpy of solution of potassium hydroxide that was different to the literature value.

Use the information given to suggest and explain **two** factors that might produce a different result. [2]

1. ....

....

2. ....

....

Examiner only

(c) Solid potassium hydroxide can be used in analysis to find the percentage of carbon dioxide present in a mixture of gases. The equation for the reaction that occurs is given below.

$$2KOH \; + \; CO_2 \longrightarrow K_2CO_3 \; + \; H_2O$$

2.0 m^3 of a gas mixture was passed through potassium hydroxide. Analysis showed that 0.050 mol of potassium carbonate had been formed.

(i) State the number of moles of carbon dioxide necessary to produce 0.050 mol of potassium carbonate. [1]

....

(ii) Calculate the volume of carbon dioxide that produced 0.050 mol of potassium carbonate. [1]

[1 mol of carbon dioxide has a volume of 24.0 dm^3 under these conditions]

Volume of carbon dioxide = ... dm^3

(iii) Calculate the percentage of carbon dioxide in the gas mixture, in terms of volume. [2]

[1 dm^3 = 0.001 m^3]

Percentage of carbon dioxide = ... %

Examiner only

(d) Scientists have commented that 'an increase in the amount of carbon dioxide dissolved in sea water will cause problems for animals whose shells are composed of calcium carbonate'.

$$CO_2(aq) + H_2O(l) + CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + 2HCO_3^-(aq)$$

Use the equation above to help you discuss the problem that is caused for these animals by this increase in carbon dioxide concentration. [3]

QWC [1]

....

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....

....

Total [15]

Examiner only

11. *(a)* An aqueous solution of methanoic acid can be used to dissolve 'lime scale' in kettles. The concentration of a methanoic acid solution used for this purpose can be found by a titration using sodium hydroxide solution. For this purpose a 25.0 cm^3 sample of aqueous methanoic acid was diluted to 250 cm^3.

(i) State the name of the piece of apparatus used to

I measure out 25.0 cm^3 of aqueous methanoic acid, [1]

....

II contain exactly 250 cm^3 of the diluted solution. [1]

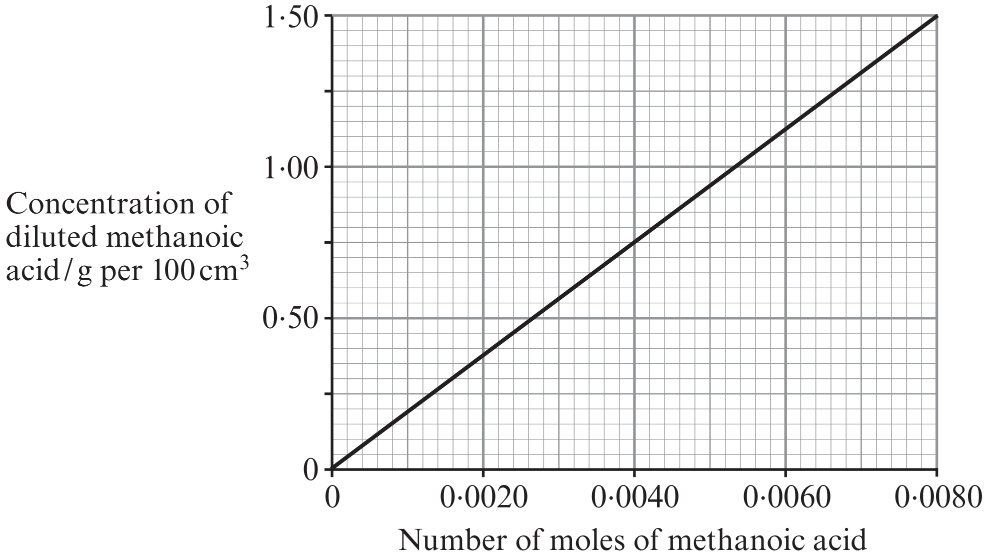
....

(ii) A 25.0 cm^3 sample of the diluted methanoic acid was titrated with sodium hydroxide solution of concentration 0.200 mol dm^{-3}. A volume of 32.00 cm^3 was needed to react with all the methanoic acid present.

Calculate the number of moles of sodium hydroxide used. [1]

Moles of sodium hydroxide = ... mol

(iii) Methanoic acid and sodium hydroxide react together in a 1:1 molar ratio. Use the graph below and your result from (ii) to find the concentration of methanoic acid present in the diluted solution in g per 100 cm^3 of solution. [1]



Concentration = ... g per 100 cm^3

(iv) State the concentration of the original methanoic acid in g per 100 cm^3 solution. [1]

Original concentration = ... g per 100 cm^3

Examiner only

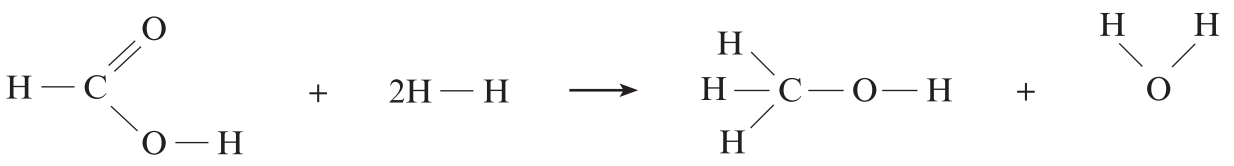
(b) Methanoic acid, HCOOH, can be reduced to methanol, CH_3OH, in a gas phase reaction, by using hydrogen in the presence of a solid ruthenium metal catalyst.

(i) Ruthenium is acting as a heterogeneous catalyst.
State the meaning of the word *heterogeneous*. [1]

....

....

(ii) The equation for the reduction of methanoic acid is shown below.



Use the table of bond enthalpies to find the enthalpy change for this reaction. [3]

Bond	Average bond enthalpy / kJ mol^{-1}
C — H	412
C — O	360
C ═ O	743
H — H	436
O — H	463

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

Examiner only

(c) The relative molecular mass of methanoic acid is 46.02.

State why this quantity does not have units. [1]

....

....

(d) Methanoic acid reacts with propan-1-ol to give 1-propyl methanoate.

$$HCOOH + CH_3CH_2CH_2OH \rightleftharpoons HCOOCH_2CH_2CH_3 + H_2O$$

1-propyl methanoate

(i) This reaction eventually reaches dynamic equilibrium.
State what is meant by *dynamic equilibrium*. [1]

....

....

....

(ii) Give the empirical formula of 1-propyl methanoate. [1]

Empirical formula ....

Total [12]

Section B Total [70]

END OF PAPER

Question number	**Additional page, if required. Write the question numbers in the left-hand margin.**

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Examiner only

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

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GCE AS/A level

1091/01-A

CHEMISTRY – PERIODIC TABLE FOR USE WITH CH1

A.M. THURSDAY, 10 January 2013

THE PERIODIC TABLE

Key: A_r = relative atomic mass; Symbol; Name; Z = atomic number

Period	1 (s Block)	2 (s Block)	d Block										3 (p Block)	4 (p Block)	5 (p Block)	6 (p Block)	7 (p Block)	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