Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1091/01

S15-1091-01

CHEMISTRY – CH1

A.M. FRIDAY, 22 May 2015

1 hour 30 minutes

1091 010001

	For Examiner's use only		
	Question	Maximum Mark	Mark Awarded
Section A	1. to 4.	10	
Section B	5.	11	
	6.	12	
	7.	14	
	8.	19	
	9.	14	
	Total	80	

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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SECTION A

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

1. Complete the table below to show the composition of the following species. [2]

Species	Protons	Neutrons	Electrons
$^{20}_{10}Ne$			
$^{18}_{8}O^{2-}$			

2. The isotope ^{226}Ra is radioactive. It decays by α-emission and has a half-life of 1600 years.

(a) Give the mass number and symbol of the species formed by the loss of one α-particle from an atom of ^{226}Ra. [1]

....

(b) State what is meant by the term *half-life*. [1]

....

....

(c) A sample of ^{226}Ra, of initial mass 1.00 g, decays for 3200 years.
Calculate the number of **moles** of ^{226}Ra left after this period. [2]

Number of moles = ... mol

3. Methanoic acid is the simplest carboxylic acid and occurs naturally, most notably in ant venom. It has a molar mass of 46.02 $g\,mol^{-1}$.

(a) State what is meant by *molar mass*. [1]

....

(b) Use the values in the table below to calculate the enthalpy change of formation for methanoic acid. [1]

$$C(s) + H_2(g) + 1\tfrac{1}{2}O_2(g) \longrightarrow HCOOH(l) + \tfrac{1}{2}O_2(g)$$

$$\searrow \qquad \swarrow$$

$$CO_2(g) + H_2O(l)$$

Substance	Enthalpy change of combustion, ΔH_c^{θ} / kJ mol^{-1}
C	−394
H_2	−286
HCOOH	−263

ΔH_f^{θ} = ... kJ mol^{-1}

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4. A sample of 0.50 g of calcium carbonate completely reacts with 50 cm^3 of hydrochloric acid solution of concentration 2.0 mol dm^{-3} to give calcium chloride, carbon dioxide and water.

(a) Suggest a method for measuring the rate of this reaction. [1]

....

....

(b) State, giving a reason, what effect using 100 cm^3 of hydrochloric acid solution of concentration 2.0 mol dm^{-3} would have on the initial rate of this reaction. [1]

....

....

Section A Total [10]

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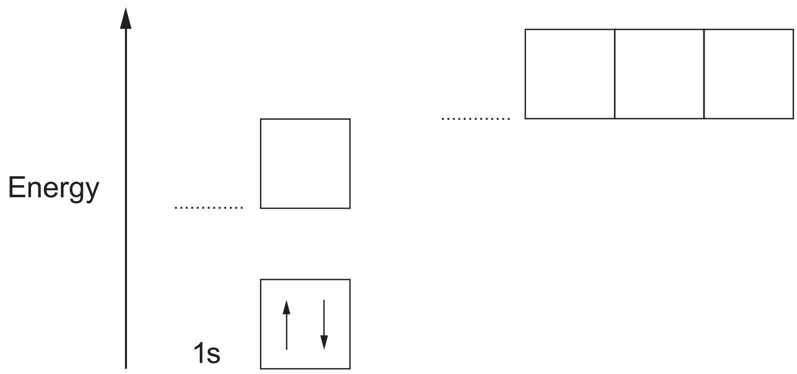
SECTION B

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

5. *(a)* Electrons are arranged in energy levels. The diagram below shows two electrons in the 1s level in a nitrogen atom.



Complete the diagram for the electrons in a nitrogen atom by labelling the sub-shell levels and showing how the electrons are arranged. [2]

(b) Nitrogen forms several oxides.

(i) An oxide of nitrogen contains 25.9 % by mass of nitrogen. Calculate the empirical formula of this oxide. [2]

Empirical formula ....

(ii) Dinitrogen oxide is formed when ammonia is oxidised.

$$\ldots\ldots\; NH_3 \;+\; \ldots\ldots\; O_2 \longrightarrow \ldots\ldots\; N_2O \;+\; \ldots\ldots\; H_2O$$

Balance the equation above. [1]

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(iii) Nitrogen dioxide is formed when calcium nitrate decomposes.

$$2Ca(NO_3)_2\,(s) \longrightarrow 2CaO(s) + 4NO_2(g) + O_2(g)$$

Calculate the total volume of gas, measured at room temperature and pressure, which would be produced when 0.886 g of calcium nitrate decomposes. [3]

[1 mol of gas occupies 24.0 dm^3 at room temperature and pressure]

Volume = ... dm^3

(c) Hydrated calcium nitrate can be represented by the formula $Ca(NO_3)_2.xH_2O$.

A 6.04 g sample of $Ca(NO_3)_2.xH_2O$ contains 1.84 g of water of crystallisation.

Calculate the value of x in $Ca(NO_3)_2.xH_2O$. You **must** show your working. [3]

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x = ...

Total [11]

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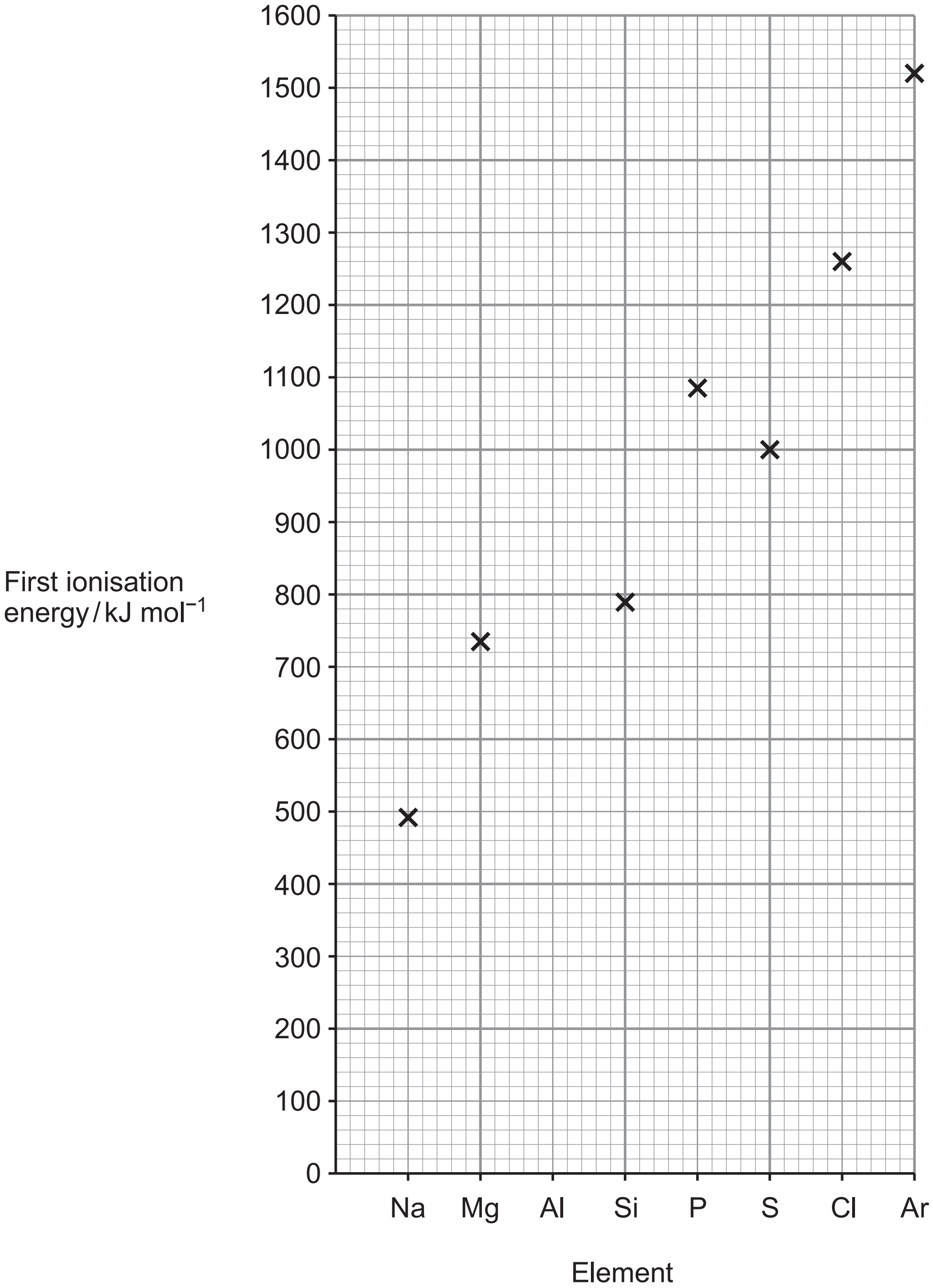
6. Ionisation energies and atomic spectra provide evidence for the arrangement of electrons in atoms.

(a) The following diagram shows the first ionisation energies of the Period 3 elements.



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(i) State the meaning of the term *molar first ionisation energy.* [2]

....

....

....

(ii) Draw a cross on the diagram to suggest the first ionisation energy of aluminium. [1]

(iii) Explain why the value of the first ionisation energy of sulfur is less than that of phosphorus. [2]

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(b) The table below gives some ionisation energies for magnesium.

	1st	2nd	3rd	4th	5th
Ionisation energy / kJ mol^{-1}	736	1450		10500	13629

(i) Explain why the second ionisation energy is greater than the first. [1]

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(ii) Complete the table by suggesting a value for the third ionisation energy of magnesium. [1]

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(c) Explain briefly how the lines in the visible atomic emission spectrum of hydrogen are formed and why the lines become closer together at the high frequency end of the spectrum. [4]

QWC [1]

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Total [12]

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7. *(a)* Lithium was discovered in 1817 by the Swedish chemist Johan August Arfwedson. Its name derives from the Greek word *lithos*, meaning 'stone', to reflect its discovery in a solid mineral, as opposed to potassium, which had been isolated from plant ashes 10 years earlier. Naturally occurring lithium is composed of two stable isotopes – ^{6}Li and ^{7}Li.

In a mass spectrometer, a sample of lithium must be ionised before it can be analysed.

(i) Describe how vaporised atoms of Li are converted into Li^{+} ions in a mass spectrometer. [2]

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(ii) Suggest why no more than the minimum energy is used to ionise the sample of lithium. [1]

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(iii) State the difference, if any, between the chemical properties of the isotopes ^{6}Li and ^{7}Li, giving a reason for your answer. [2]

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(b) The mass spectrum of a naturally occurring sample of lithium gave the following results.

Isotope	% abundance
^{6}Li	7.25
^{7}Li	92.75

These results can be used to determine the relative atomic mass of the lithium sample.

(i) Calculate the relative atomic mass of the sample. [2]

Relative atomic mass = ...

Examiner only

(ii) State and explain which of the Li^+ ions formed from the isotopes of Li will be deflected more in a mass spectrometer. [1]

....

....

(c) Lithium hydroxide reacts with ammonium sulfate to form ammonia, lithium sulfate and water as shown in the equation below.

$$(NH_4)_2SO_4 \quad + \quad 2LiOH \longrightarrow 2NH_3 \quad + \quad Li_2SO_4 \quad + \quad 2H_2O$$

A 2.06 g sample of ammonium sulfate reacted exactly with 29.80 cm^3 of a lithium hydroxide solution.

(i) Calculate the amount, in moles, of $(NH_4)_2SO_4$ in 2.06 g of ammonium sulfate. Give your answer to **three** significant figures. [2]

Number of moles = ... mol

(ii) Calculate the concentration, in mol dm^{-3}, of the lithium hydroxide solution used. [2]

Concentration = ... mol dm^{-3}

(iii) Calculate the percentage atom economy for the production of ammonia in the reaction between ammonium sulfate and lithium hydroxide. [2]

Atom economy = ... %

Total [14]

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8. *(a)* Planners have to ensure a secure supply of energy in the future. It has been suggested that the use of fossil fuels should be reduced, the use of renewable energy increased and that energy efficiency should be greatly improved.

By considering both the benefits and the difficulties involved, discuss whether you think that these suggestions are realistic. [4]
QWC [1]

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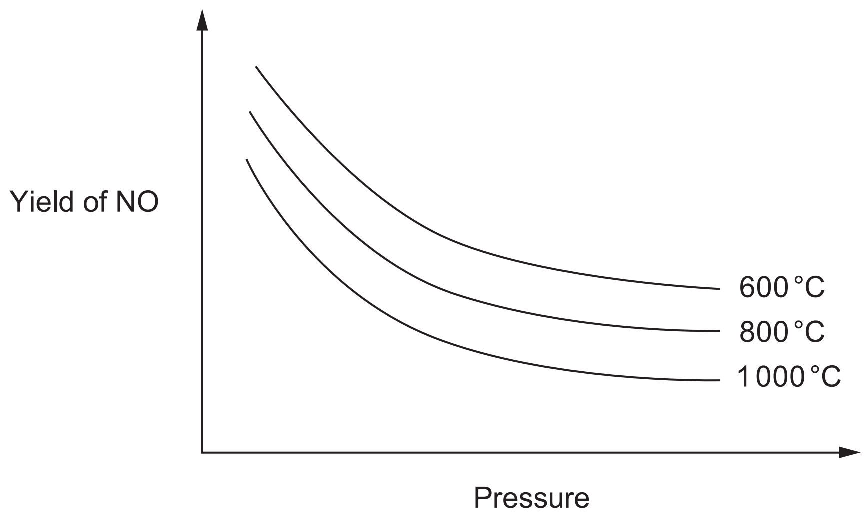
(b) Nitric acid is produced by the Ostwald process.

The first stage involves the oxidation of ammonia over a platinum/rhodium catalyst.

ammonia + oxygen $\rightleftharpoons$ nitric oxide + water

The graph below shows how the yield of nitric oxide, NO, depends on the temperature and pressure used in its production.



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(i) I. State the general variations in this yield with temperature and pressure. [1]

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II. Use the graphs to explain whether the reaction is endothermic or exothermic and whether there are more moles of gaseous products than reactants. [4]
QWC [1]

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(ii) Normally the process is carried out at a temperature of around 900 °C. Suggest why this temperature is used. [2]

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(iii) State the **type** of catalyst used. [1]

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(iv) Explain why there has been much research to find a better catalyst. [2]

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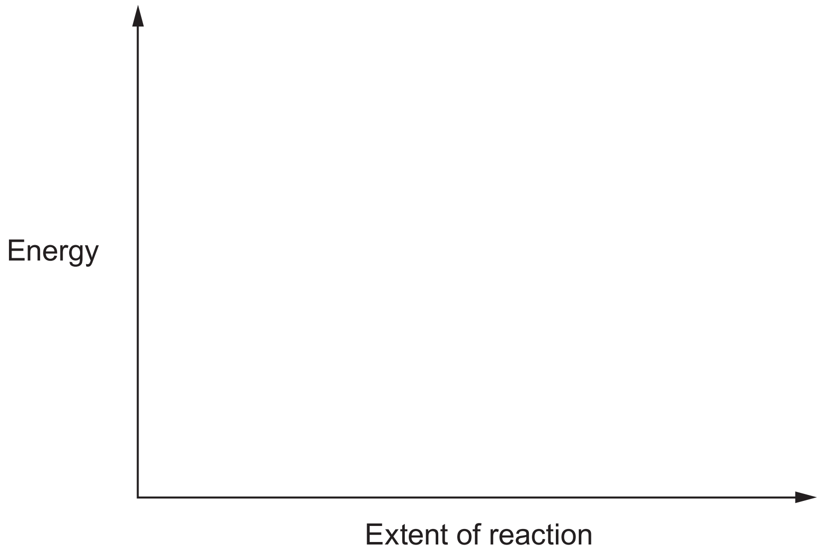
Examiner only

(v) The next stage in the Ostwald process is to convert the nitric oxide to nitrogen dioxide.

$$2NO(g) \quad + \quad O_2(g) \longrightarrow 2NO_2(g) \qquad \Delta H = -114 \text{ kJ mol}^{-1}$$

Sketch on the axes below the energy profile for this reaction, clearly labelling the enthalpy change of reaction, ΔH. [2]



(vi) Write an expression that connects the enthalpy change of a reaction, ΔH, with the activation energies of the forward (E_f) and reverse (E_b) reactions. [1]

....

Total [19]

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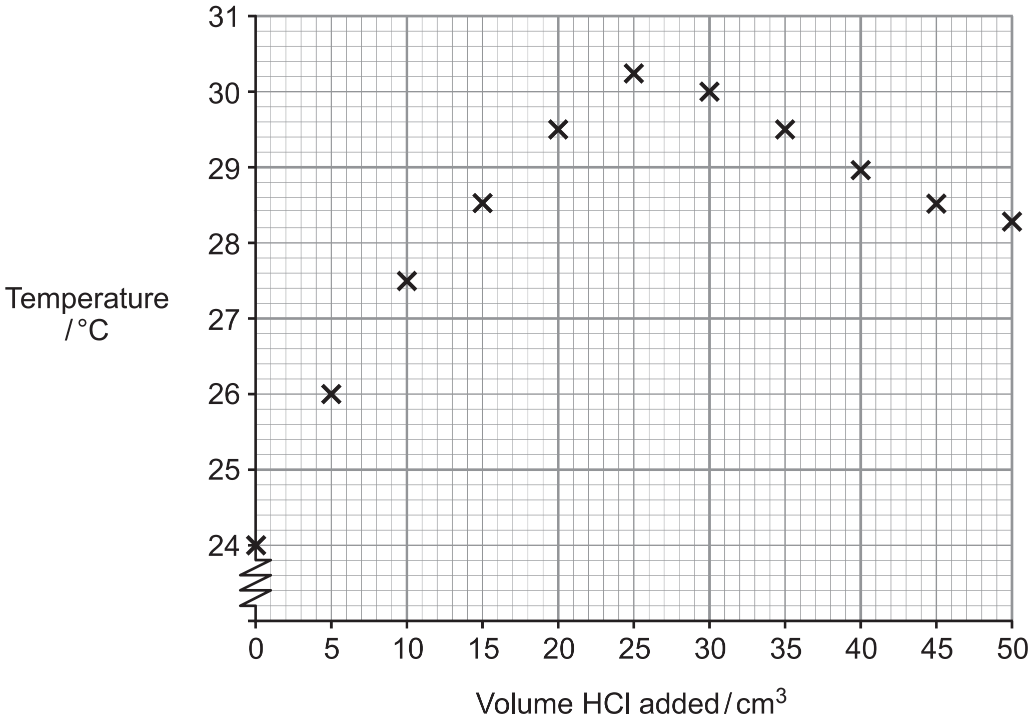
9. Zac was asked to measure the molar enthalpy change of neutralisation of sodium hydroxide by hydrochloric acid.

$$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

He was told to use the following method:

- Measure 25.0 cm^3 of sodium hydroxide solution of concentration 0.970 mol dm^{-3} into a polystyrene cup.
- Measure the temperature of the solution.
- Place the hydrochloric acid solution into a suitable container and measure the temperature of the solution.
- When the temperatures of both solutions are equal add 5.00 cm^3 of hydrochloric acid to the sodium hydroxide and stir.
- Measure the temperature of the mixture.
- Keep adding 5.00 cm^3 portions of hydrochloric acid, until 50.0 cm^3 have been added, stirring and measuring the temperature each time.

Zac's results are shown on the graph below.



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(a) Suggest why it is important that the hydrochloric acid and the sodium hydroxide are at the same temperature. [1]

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....

(b) By drawing lines of best fit for both sets of points determine:

(i) the maximum temperature **change** [2]

Maximum temperature rise from the graph = ... °C

(ii) the volume of acid required to neutralise the sodium hydroxide. [1]

Volume of acid = ... cm^3

(c) Use your value from part *(b)*(ii) to calculate the concentration, in mol dm^{-3}, of the hydrochloric acid solution. [2]

Concentration = ... mol dm^{-3}

(d) Use **both** values from part *(b)* to calculate the heat given out during **this** experiment.

[Assume that the density of the solution is 1.00 g cm^{-3} and that its specific heat capacity is 4.18 J K^{-1} g^{-1}] [1]

Heat given out = ... J

(e) Calculate the molar enthalpy change, ΔH, for the reaction between sodium hydroxide and hydrochloric acid. [2]

ΔH = ... kJ mol^{-1}

Examiner only

(f) Name a piece of apparatus that Zac could use to measure exactly 25.0 cm^3 of the sodium hydroxide solution. [1]

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(g) Explain why the temperature falls on continuing to add hydrochloric acid **after** the maximum temperature has been reached. [2]

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(h) The data book value for this molar enthalpy change of neutralisation is more exothermic than Zac's value.

State the **main** reason for the difference between the values and suggest **one** change that would improve his result. [2]

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Total [14]

Section B Total [70]

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GCE AS/A level

1091/01-A

S15-1091-01A

CHEMISTRY – PERIODIC TABLE
FOR USE WITH CH1

A.M. FRIDAY, 22 May 2015

THE PERIODIC TABLE

Group

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

s Block (Groups 1–2) · d Block · p Block (Groups 3–0) · f Block

Period	1	2											3	4	5	6	7	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