Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
January 2003
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

CHEMISTRY CHM2
Unit 2 Foundation Physical and Inorganic Chemistry

Friday 10 January 2003 Morning Session

In addition to this paper you will require:
a calculator.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided. All working must be shown.
- Do all rough work in this book. Cross through any work you do not want marked.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information
- The maximum mark for this paper is 90.
- Mark allocations are shown in brackets.
- This paper carries 30 per cent of the total marks for AS. For Advanced Level this paper carries 15 per cent of the total marks.
- You are expected to use a calculator where appropriate.
- The following data may be required.
  Gas constant $R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$
- Your answers to questions in **Section B** should be written in continuous prose, where appropriate. You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.

Advice
- You are advised to spend about 1 hour on **Section A** and about 30 minutes on **Section B**.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

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

1 The table below contains some standard enthalpy of formation data.

Substance	C(s)	$N_2(g)$	$H_2O(g)$	$CO_2(g)$	$NH_4NO_3(s)$
$\Delta H_f^{\ominus}$/ kJ mol^{-1}	0	0	–242	–394	–365

(a) Why are the values of the standard enthalpy of formation for carbon and nitrogen zero?

.....

(1 mark)

(b) State Hess's Law.

.....

.....

.....

(2 marks)

(c) Use $\Delta H_f^{\ominus}$ data from the table to calculate a value for the enthalpy change for the following reaction.

$$NH_4NO_3(s) + \tfrac{1}{2}C(s) \rightarrow N_2(g) + 2H_2O(g) + \tfrac{1}{2}CO_2(g)$$

.....

.....

.....

.....

(3 marks)

6

The Periodic Table of the Elements

■ The atomic numbers and approximate relative atomic masses shown in the table are for use in the examination unless stated otherwise in an individual question.

I	II										III	IV	V	VI	VII	0
1.0 **H** Hydrogen 1																4.0 **He** Helium 2
6.9 **Li** Lithium 3	9.0 **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
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** Sulphur 16	35.5 **Cl** Chlorine 17	39.9 **Ar** Argon 18
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
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	101.1 **Ru** Ruthenium 44	102.9 **Rh** Rhodium 45	106.4 **Pd** Palladium 46	107.9 **Ag** Silver 47	112.4 **Cd** Cadmium 48	114.8 **In** Indium 49	118.7 **Sn** Tin 50	121.8 **Sb** Antimony 51	127.6 **Te** Tellurium 52	126.9 **I** Iodine 53	131.3 **Xe** Xenon 54
132.9 **Cs** Caesium 55	137.3 **Ba** Barium 56	138.9 **La** Lanthanum 57 *	178.5 **Hf** Hafnium 72	180.9 **Ta** Tantalum 73	183.9 **W** Tungsten 74	186.2 **Re** Rhenium 75	190.2 **Os** Osmium 76	192.2 **Ir** Iridium 77	195.1 **Pt** Platinum 78	197.0 **Au** Gold 79	200.6 **Hg** Mercury 80	204.4 **Tl** Thallium 81	207.2 **Pb** Lead 82	209.0 **Bi** Bismuth 83	210.0 **Po** Polonium 84	210.0 **At** Astatine 85	222.0 **Rn** Radon 86
223.0 **Fr** Francium 87	226.0 **Ra** Radium 88	227 **Ac** Actinium 89 †															

Key

relative atomic mass — 6.9 **Li** Lithium

atomic number — 3

140.1 **Ce** Cerium 58	140.9 **Pr** Praseodymium 59	144.2 **Nd** Neodymium 60	144.9 **Pm** Promethium 61	150.4 **Sm** Samarium 62	152.0 **Eu** Europium 63	157.3 **Gd** Gadolinium 64	158.9 **Tb** Terbium 65	162.5 **Dy** Dysprosium 66	164.9 **Ho** Holmium 67	167.3 **Er** Erbium 68	168.9 **Tm** Thulium 69	173.0 **Yb** Ytterbium 70	175.0 **Lu** Lutetium 71
232.0 **Th** Thorium 90	231.0 **Pa** Protactinium 91	238.0 **U** Uranium 92	237.0 **Np** Neptunium 93	239.1 **Pu** Plutonium 94	243.1 **Am** Americium 95	247.1 **Cm** Curium 96	247.1 **Bk** Berkelium 97	252.1 **Cf** Californium 98	(252) **Es** Einsteinium 99	(257) **Fm** Fermium 100	(258) **Md** Mendelevium 101	(259) **No** Nobelium 102	(260) **Lr** Lawrencium 103

* **58 – 71** Lanthanides

† **90 – 103** Actinides

Table 1
Proton n.m.r chemical shift data

Type of proton	**δ/ppm**
RCH_3	0.7–1.2
R_2CH_2	1.2–1.4
R_3CH	1.4–1.6
$RCOCH_3$	2.1–2.6
$ROCH_3$	3.1–3.9
$RCOOCH_3$	3.7–4.1
ROH	0.5–5.0

Table 2
Infra-red absorption data

Bond	**Wavenumber/cm^{-1}**
C—H	2850–3300
C—C	750–1100
C═C	1620–1680
C═O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

2 The table below contains some mean bond enthalpy data.

Bond	H—H	C—C	C=C	N≡N	N—H
Mean bond enthalpy / kJ mol^{-1}	436	348	612	944	388

(a) Explain the term *mean bond enthalpy*.

.....

.....

.....

.....

(2 marks)

(b) (i) Write an equation for the formation of one mole of ammonia, NH_3, from its elements.

.....

(ii) Use data from the table above to calculate a value for the enthalpy of formation of ammonia.

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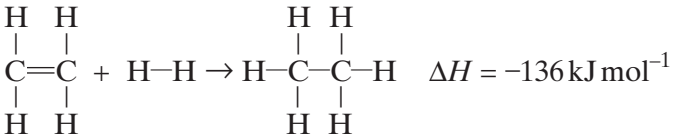
.....

.....

.....

(4 marks)

(c) Use the following equation and data from the table above to calculate a value for the C–H bond enthalpy in ethane.



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(3 marks)

9

3 (a) Define the term *activation energy* for a reaction.

.....

.....

(2 marks)

(b) Give the meaning of the term *catalyst*.

.....

.....

(2 marks)

(c) Explain in general terms how a catalyst works.

.....

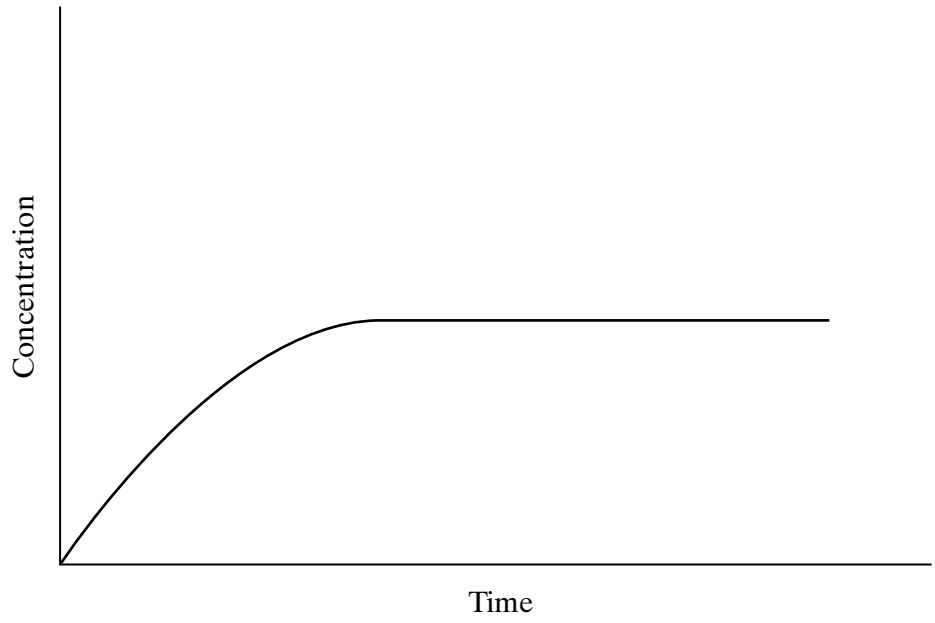
.....

(2 marks)

(d) In an experiment, two moles of gas **W** reacted completely with solid **Y** to form one mole of gas **Z** as shown in the equation below.

$$2W(g) + Y(s) \rightarrow Z(g)$$

The graph below shows how the concentration of **Z** varied with time at constant temperature.



(i) On the axes above, sketch a curve to show how the concentration of **W** would change with time in the same experiment. Label this curve **W**.

(ii) On the axes above, sketch a curve to show how the concentration of **Z** would change with time if the reaction were to be repeated under the same conditions but in the presence of a catalyst. Label this curve **Z**.

(iii) In terms of the behaviour of particles, explain why the rate of this reaction decreases with time.

.....

.....

(6 marks)

12

4 Methanol can be synthesised from carbon monoxide by the reversible reaction shown below.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g) \quad \Delta H = -91\,kJ\,mol^{-1}$$

The process operates at a pressure of 5 MPa and a temperature of 700 K in the presence of a copper-containing catalyst. This reaction can reach dynamic equilibrium.

(a) By reference to rates and concentrations, explain the meaning of the term *dynamic equilibrium*.

.....

.....

(2 marks)

(b) Explain why a high yield of methanol is favoured by high pressure.

.....

.....

(2 marks)

(c) Suggest **two** reasons why the operation of this process at a pressure much higher than 5 MPa would be very expensive.

Reason 1 .....

Reason 2 .....

(2 marks)

(d) State the effect of an increase in temperature on the equilibrium yield of methanol and explain your answer.

Effect .....

Explanation .....

.....

.....

(3 marks)

(e) If a catalyst were not used in this process, the operating temperature would have to be greater than 700 K. Suggest why an increased temperature would be required.

.....

(1 mark)

10

5 (a) State and explain the trend in electronegativity down Group VII from fluorine to iodine.

Trend .....

Explanation .....

.....

(3 marks)

(b) (i) Describe what you would observe when an aqueous solution of bromine is added to an aqueous solution containing iodide ions. Write an equation for the reaction occurring.

Observation .....

Equation .....

(ii) Explain why bromine does not react with aqueous chloride ions.

.....

.....

(3 marks)

(c) Describe what you would observe when aqueous silver nitrate is added to separate aqueous solutions of potassium fluoride and potassium bromide.

Observation with KF(aq) .....

Observation with KBr(aq) .....

(2 marks)

(d) Write an equation to show how solid potassium fluoride reacts with concentrated sulphuric acid.

.....

(1 mark)

(e) Write an equation for the redox reaction of sodium bromide with concentrated sulphuric acid.

.....

(2 marks)

11

6 (a) In acidic conditions, hydrogen peroxide, H_2O_2, oxidises iodide ions to iodine. The hydrogen peroxide is reduced to water. In H_2O_2, oxygen has an oxidation state of –1.

(i) Construct a half-equation for the reduction of hydrogen peroxide to water in acidic conditions.

.....

(ii) Construct a half-equation for the oxidation of I^- ions to iodine.

.....

(iii) Construct an equation for the overall reaction.

.....

(3 marks)

(b) The concentration of an aqueous iodine solution can be determined by titration with aqueous sodium thiosulphate. In a titration, 25.0 cm^3 of an aqueous iodine solution reacted with exactly 19.5 cm^3 of a 0.120 mol dm^{-3} solution of sodium thiosulphate.

(i) Write an equation for the reaction between iodine and thiosulphate ions.

.....

(ii) Calculate the concentration of the iodine solution.

(If you are unable to answer part (b)(i), assume that one mole of iodine reacts with three moles of thiosulphate ions. This is not the correct ratio.)

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(5 marks)

(c) Chlorine reacts with water as shown in the following equation.

$$Cl_2 + H_2O \rightleftharpoons Cl^- + HClO + H^+$$

In this reaction, chlorine acts both as an oxidising agent and as a reducing agent.

(i) Construct a half-equation for the reduction of chlorine to chloride ions.

.....

(ii) Deduce the oxidation state of chlorine in HClO.

.....

(iii) Construct a half-equation for the oxidation of chlorine, in reaction with water, to form HClO and H^+ ions.

.....

(iv) Give **one** reason why chlorine is used in the water industry.

.....

(4 marks)

12

TURN OVER FOR THE NEXT QUESTION

SECTION B

Answer the question below in the space provided on pages 12 to 16 of this booklet.

7 In this question, credit will be given for appropriate equations.

(a) Describe the process by which titanium metal is extracted from titanium(IV) oxide. Explain why this extraction process causes titanium to be an expensive metal. *(11 marks)*

(b) Explain how the impurity silicon(IV) oxide is removed during the extraction of iron in the Blast Furnace.
Discuss the chemical reactions by which impurities are removed from iron in the basic oxygen converter. *(13 marks)*

(c) Describe how scrap iron is recycled. Discuss the social and environmental benefits of this recycling. *(6 marks)*

END OF QUESTIONS