Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Friday 16 January 2009 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH02/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/7/2/2

N 3 4 0 8 0 A 0 1 2 0

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 10.0 cm^3 of 0.250 mol dm^{-3} potassium hydroxide solution was placed in a conical flask and titrated with 0.200 mol dm^{-3} hydrochloric acid solution, using phenolphthalein as an indicator.

(a) What colour would phenolphthalein turn at the end-point in this titration?

(1)

☒ **A** Colourless

☒ **B** Pink

☒ **C** Yellow

☒ **D** Orange

(b) The best piece of apparatus to accurately measure out 10.0 cm^3 is a

(1)

☒ **A** pipette.

☒ **B** burette.

☒ **C** syringe.

☒ **D** measuring cylinder.

(c) What volume of 0.200 mol dm^{-3} hydrochloric acid solution was added by the end-point?

(1)

☒ **A** 8.00 cm^3

☒ **B** 10.00 cm^3

☒ **C** 12.50 cm^3

☒ **D** 25.00 cm^3

(Total for Question 1 = 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

2 Which of these metal hydroxides is the most soluble in water?

☒ **A** Barium hydroxide

☒ **B** Calcium hydroxide

☒ **C** Magnesium hydroxide

☒ **D** Strontium hydroxide

(Total for Question 2 = 1 mark)

3 Which of these metals will give a lilac flame colour?

☒ **A** Sodium

☒ **B** Calcium

☒ **C** Potassium

☒ **D** Magnesium

(Total for Question 3 = 1 mark)

4 Which of these is a tertiary alcohol?

☒ **A** 3-methylpentan-2-ol

☒ **B** Pentan-2-ol

☒ **C** Pentan-3-ol

☒ **D** 2-methylpentan-2-ol

(Total for Question 4 = 1 mark)

5 Which of these statements about fluorine is **not** correct?

☒ **A** It is a gaseous element at room temperature and pressure.

☒ **B** It can react with chloride ions to form chlorine.

☒ **C** It forms salts with Group 1 metals.

☒ **D** It is less electronegative than chlorine.

(Total for Question 5 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

6 What is the oxidation number of oxygen in dioxygen difluoride, O_2F_2?

☒ **A** –1

☒ **B** –2

☒ **C** +1

☒ **D** +2

(Total for Question 6 = 1 mark)

7 Which of these four molecules, PCl_3, CO, CO_2 and CCl_4, are polar?

☒ **A** All four

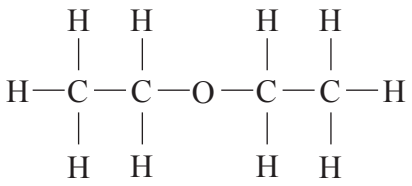
☒ **B** PCl_3 and CO

☒ **C** CO and CCl_4

☒ **D** PCl_3 and CO_2

(Total for Question 7 = 1 mark)

8 Which intermolecular forces exist between molecules of ethoxyethane?



☒ **A** Instantaneous dipole – induced dipole only

☒ **B** Permanent dipole – permanent dipole only

☒ **C** Instantaneous dipole – induced dipole and hydrogen bonds

☒ **D** Instantaneous dipole – induced dipole and permanent dipole – permanent dipole

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 The following liquids all have the same number of electrons in each molecule. Which one is likely to have the lowest boiling point?

☒ **A** $CH_3CH_2CH_2CH_2OH$

☒ **B** $CH_3CH_2CH_2CH_2CH_3$

☒ **C** $CH_3C(CH_3)_2CH_3$

☒ **D** $CH_3CH(CH_3)CH_2CH_3$

(Total for Question 9 = 1 mark)

10 Which of these is likely to be the best solvent for cyclohexanol?

☒ **A** $H_2O(l)$

☒ **B** $CH_3COCH_3(l)$

☒ **C** NaCl(aq)

☒ **D** $CH_3CH_2CH_2CH_2CH_2CH_3(l)$

(Total for Question 10 = 1 mark)

11 The ability of a liquid to flow is linked to the strength of its intermolecular forces. Suggest which of these liquids flows the slowest when poured.

☒ **A** Propane-1,2,3-triol

☒ **B** Propane-1,2-diol

☒ **C** Pentane

☒ **D** Butane

(Total for Question 11 = 1 mark)

12 What type of species forms when a bond breaks homolytically?

☒ **A** Nucleophile

☒ **B** Electron

☒ **C** Electrophile

☒ **D** Free radical

(Total for Question 12 = 1 mark)

13 In the reaction between $Ag^+(aq)$ ions and $Fe^{2+}(aq)$ ions, what would be the effect of increasing the concentration of $Ag^+(aq)$ ions?

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Fe^{3+}(aq) + Ag(s)$$

☒ **A** Rate of reaction increases, yield of $Fe^{3+}(aq)$ stays the same.

☒ **B** Rate of reaction increases, yield of $Fe^{3+}(aq)$ decreases.

☒ **C** Rate of reaction decreases, yield of $Fe^{3+}(aq)$ stays the same.

☒ **D** Rate of reaction increases, yield of $Fe^{3+}(aq)$ increases.

(Total for Question 13 = 1 mark)

14 Which one of these reactions is **not** a disproportionation reaction?

☒ **A** $2H_2O_2(aq) \rightarrow O_2(g) + 2H_2O(l)$

☒ **B** $S_2O_3^{2-}(aq) + 2H^+(aq) \rightarrow SO_2(g) + S(s) + H_2O(l)$

☒ **C** $Cl_2(aq) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

☒ **D** $2Cu^+(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$

(Total for Question 14 = 1 mark)

15 Molecules absorb IR radiation because

☒ **A** they change their polarity when they vibrate.

☒ **B** they change their velocity when they vibrate.

☒ **C** they change their magnetic field when they vibrate.

☒ **D** they change their direction of rotation when they vibrate.

(Total for Question 15 = 1 mark)

16 How many of the following molecules will absorb IR radiation?

H_2O N_2 CH_4 O_2 CO_2

☒ **A** Two

☒ **B** Three

☒ **C** Four

☒ **D** Five

(Total for Question 16 = 1 mark)

17 Infrared (IR) spectra can be used to follow the progress of reactions involving propan-1-ol and propan-2-ol. Some absorption ranges by chemical bonds in the IR spectrum are given below.

1 O—H stretching in alcohols at 3750 − 3200 cm^{-1}

2 C═O stretching in aldehydes at 1740 − 1720 cm^{-1}

3 C═O stretching in ketones at 1700 − 1680 cm^{-1}

4 C═O stretching in carboxylic acids at 1725 − 1700 cm^{-1}

(a) To identify the formation of the product when propan-1-ol has been partially oxidized, you can look for absorptions in the IR spectrum at absorption range

(1)

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(b) To monitor whether all of the sample of propan-2-ol has been oxidized, you can look for

(1)

☒ **A** a lack of absorptions in the IR spectrum at 1.

☒ **B** a lack of absorptions in the IR spectrum at 2.

☒ **C** absorptions in the IR spectrum at 3.

☒ **D** absorptions in the IR spectrum at 4.

(Total for Question 17 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 This question is about the reactions and properties of some halogenoalkanes.

(a) State the reagents and conditions needed to convert the following halogenoalkanes into the named product.

(i) 1-bromobutane into butan-1-ol

(2)

(ii) 1-iodobutane into butylamine

(2)

(iii) 2-chloropropane into propene

(2)

(b) Chloroethane can be prepared by reacting ethanol with potassium chloride in the presence of concentrated sulfuric acid.

Explain why a similar reaction using potassium iodide and concentrated sulfuric acid should **not** be used to prepare iodoethane.

(2)

(c) Two gaseous halogenoalkanes that could be used as fire retardants have the structural formulae CF_2ClBr and CF_3CHF_2.

(i) Give the systematic name of CF_2ClBr.

(1)

(ii) Draw the **skeletal** formula of CF_3CHF_2.

(1)

(iii) Suggest TWO reasons to explain how these compounds can help put out fires.

(2)

*(iv) Explain why fire retardants containing some halogenoalkanes, such as CF_2ClBr, are being phased out.

Suggest a reason why the scientific community still supports the use of fire retardants containing CF_3CHF_2.

(4)

(Total for Question 18 = 16 marks)

19 10.0 cm^3 of a solution containing $Cu^{2+}(aq)$ ions was added to excess potassium iodide solution and the following reaction occurred.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

(a) What happens to the $Cu^{2+}(aq)$ during this reaction? Justify your answer.

(2)

.....

.....

.....

.....

.....

(b) All of the mixture containing iodine was titrated using sodium thiosulfate solution of concentration 0.200 mol dm^{-3}. The volume of sodium thiosulfate solution added at the end-point was 12.75 cm^3.

The equation for the reaction is

$$I_2(aq) + 2Na_2S_2O_3(aq) \rightarrow Na_2S_4O_6(aq) + 2NaI(aq)$$

(i) The end-point is shown most effectively using an indicator. State a suitable indicator and the colour change you would expect to see at the end-point.

(2)

Indicator

.....

Colour change at end-point

.....

(ii) Calculate the number of moles of iodine in the solution.

(2)

*(iii) Use your answer from (ii), and the equation for the reaction between $Cu^{2+}(aq)$ and $I^{-}(aq)$, to calculate the concentration of the $Cu^{2+}(aq)$ in the original sample of solution.

Give your answer to **three** significant figures and justify why this is an appropriate level of accuracy.

(3)

(iv) The whole of the solution containing iodine was used in one titration. Explain how this affects the reliability of your answer to (iii).

(1)

(Total for Question 19 = 10 marks)

20 This question is about boron and nitrogen compounds.

(a) Draw and name the shape of a boron trifluoride, BF_3, molecule. Suggest the FBF bond angle.

(3)

Name of shape

FBF bond angle

(b) Ammonia has the formula NH_3. Its HNH bond angle is less than the FBF bond angle in boron trifluoride.

(i) Estimate the HNH bond angle in NH_3.

(1)

(ii) Explain why the HNH bond angle is less than that for FBF.

(1)

(iii) Name the strongest intermolecular force between BF_3 molecules.

(1)

(iv) Name the strongest intermolecular force between NH_3 molecules.

(1)

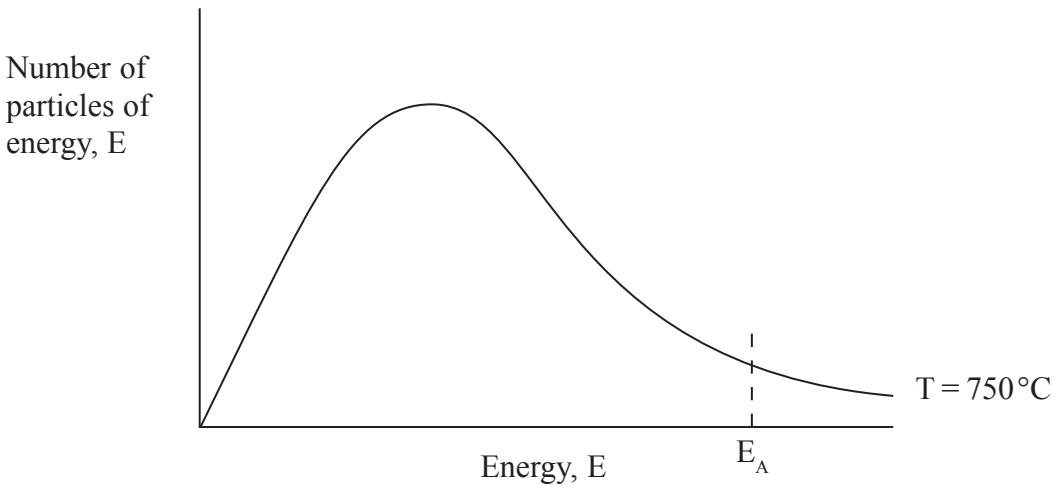
(c) Ammonia will react with oxygen in the presence of a platinum catalyst at 750 °C forming water and nitrogen(II) oxide, NO.

(i) What is the oxidation number of nitrogen in ammonia, NH_3?

(1)

(ii) The diagram below shows the distribution of molecular energies in the reaction at 750 °C. On the same diagram, draw a curve to show the distribution at 500 °C and explain what effect this change in temperature would have on the rate of the reaction.

(3)



*(d) Explain how a catalyst speeds up the rate of a reaction.

(3)

(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

21 Ethanoic acid is used industrially in the manufacture of polymers and glues and also in the food industry as an acidity regulator.

It can be synthesized in the laboratory by the reaction of ethanol with excess sodium dichromate(VI) solution, acidified with concentrated sulfuric acid. Ethanol is placed in a suitable flask along with some anti-bumping beads. The concentrated sulfuric acid is then added a drop at a time. The sodium dichromate(VI) solution is then added a drop at a time causing the mixture to boil spontaneously. When the addition of the sodium dichromate(VI) solution is complete, the mixture is heated under reflux for approximately 15 minutes. The ethanoic acid formed can then be separated from the reaction mixture.

$$CH_3CH_2OH \xrightarrow[\text{heat, 1 atm}]{\substack{Na_2Cr_2O_7 \\ H_2SO_4}} CH_3COOH$$

Ethanoic acid can be produced industrially by the Cativa™ process. Methanol, which can be obtained from wood, is reacted with carbon monoxide in the presence of an iridium catalyst.

$$CH_3OH(g) + CO(g) \underset{\text{190 °C}}{\overset{\text{Iridium catalyst, 20–30 atm}}{\rightleftharpoons}} CH_3COOH(g)$$

(a) (i) Balance the half-equation for the reduction of dichromate(VI) ions.

(1)

$Cr_2O_7^{2-}$ + ... H^+ + ... e^- → ..... Cr^{3+} + ... H_2O

(ii) The half-equation for the oxidation of ethanol is

$$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$$

Use this and your answer to (a)(i) to write a full equation for the overall reaction between acidified dichromate(VI) ions and ethanol. State symbols are **not** required.

(2)

(b) (i) Why are the concentrated sulfuric acid and sodium dichromate(VI) added a drop at a time in the laboratory process?

(1)

.....

.....

(ii) Draw a labelled diagram of the apparatus that could be used to heat the mixture under reflux.

(3)

(iii) What colour would the mixture be after it was heated under reflux?

(1)

.....

(c) A solution containing both water and ethanoic acid is produced by distillation of the final reaction mixture.

(i) Explain why the other products and any excess reactants are left behind in the distillation flask.

(1)

(ii) Suggest a method to separate pure ethanoic acid, boiling temperature 118 °C, from the water.

(1)

(d) (i) In the Cativa™ process what effect, if any, would increasing the pressure have on the yield of ethanoic acid? Justify your answer.

(2)

(ii) Suggest TWO reasons why it might be difficult, or undesirable, to produce ethanoic acid in industry by scaling up the laboratory process.

(2)

*(e) An alternative industrial process for the production of ethanoic acid is the oxidation of butane using a transition metal catalyst at 150 °C and 55–60 atm.

$$2C_4H_{10}(l) + 5O_2(g) \rightarrow 4CH_3COOH(aq) + 2H_2O(l)$$

Evaluate the 'greenness' and sustainability of the two industrial processes.

Suggest TWO additional pieces of information that would help you make a more informed decision.

(6)

(Total for Question 21 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS

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Turn over ▶

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 **H** hydrogen 1										(18) 4.0 **He** helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
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	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(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	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] **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	183.8 **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	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **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
* Actinide series	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