



Surname					Other Names				
Centre Number					Candidate Number				
Candidate Signature									

General Certificate of Education
January 2003
Advanced Level Examination



CHEMISTRY
Unit 6a Synoptic Assessment

CHM6/W

Friday 24 January 2003 Afternoon Session

In addition to this paper you will require:

- an objective test answer sheet;
- a calculator.

Time allowed: 1 hour

Instructions

- Use a blue or black ball-point pen. Do **not** use pencil.
- Fill in the boxes at the top of this page.
- Answer **all** 40 questions.
- For each item there are four responses. When you have selected the response which you think is the best answer to a question, mark this response on your answer sheet.
- Mark all responses as instructed on your answer sheet. If you wish to change your answer to a question, follow the instructions on your answer sheet.
- Do all rough work in this book, **not** on your answer sheet.
- Make sure that you hand in **both** your answer sheet **and** this question paper at the end of this examination.
- The Periodic Table/Data Sheet is provided on pages 3 and 4. Detach this perforated sheet at the start of the examination.

Information

- Each correct answer will score one mark. No deductions will be made for wrong answers.
- This paper carries 10 per cent of the total marks for Advanced Level.
- The following data may be required.
Gas constant $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Advice

- Do not spend too long on any question. If you have time at the end, go back and answer any question you missed out.

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

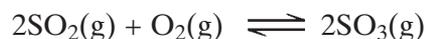
Bond	Wavenumber/ cm^{-1}
C—H	2850–3300
C—C	750–1100
C=C	1620–1680
C=O	1680–1750
C—O	1000–1300
O—H (alcohols)	3230–3550
O—H (acids)	2500–3000

Multiple choice questions

Each of Questions 1 to 21 consists of a question or an incomplete statement followed by four suggested answers or completions. You are to select the most appropriate answer in each case.

Questions 1 to 5

Questions 1 to 5 relate to the equilibrium gas-phase synthesis of sulphur trioxide:



Thermodynamic data for the components of this equilibrium are:

Substance	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$	$S^\ominus / \text{J K}^{-1} \text{mol}^{-1}$
$\text{SO}_3(\text{g})$	-396	+257
$\text{SO}_2(\text{g})$	-297	+248
$\text{O}_2(\text{g})$	0	+204

This equilibrium, at a temperature of 585 K and a total pressure of 540 kPa, occurs in a vessel of volume 1.80 dm^3 . At equilibrium, the vessel contains 0.0500 mol of $\text{SO}_2(\text{g})$, 0.0800 mol of $\text{O}_2(\text{g})$ and 0.0700 mol of $\text{SO}_3(\text{g})$.

- The mole fraction of SO_3 in the equilibrium mixture is
 - 0.250
 - 0.350
 - 0.440
 - 0.700
- With pressures expressed in MPa units, the value of the equilibrium constant, K_p , is
 - 4.90
 - 6.48
 - 9.07
 - 16.8

Turn over ►

3 Possible units for the equilibrium constant K_p include

- A no units
- B kPa
- C MPa^{-1}
- D kPa^{-2}

4 The standard entropy change for this reaction is

- A $-222 \text{ J K}^{-1} \text{ mol}^{-1}$
- B $-195 \text{ J K}^{-1} \text{ mol}^{-1}$
- C $-186 \text{ J K}^{-1} \text{ mol}^{-1}$
- D $+198 \text{ J K}^{-1} \text{ mol}^{-1}$

5 At equilibrium in the same vessel of volume 1.80 dm^3 under altered conditions, the reaction mixture contains 0.0700 mol of $\text{SO}_3(\text{g})$, 0.0500 mol of $\text{SO}_2(\text{g})$ and 0.0900 mol of $\text{O}_2(\text{g})$ at a total pressure of 623 kPa . The temperature in the equilibrium vessel is

- A 307°C
- B 596 K
- C 337°C
- D 642 K

6 An aqueous solution contains 4.0 g of sodium hydroxide in 250 cm^3 of solution.
($K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$)

The pH of the solution is

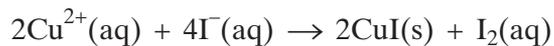
- A 13.0
- B 13.3
- C 13.6
- D 13.9

- 7 Which one of the following best explains why the lattice enthalpy of magnesium chloride is much larger than that of lithium chloride?
- A Magnesium has a greater electronegativity than lithium.
 - B Magnesium ions have a greater polarising power than lithium ions.
 - C Magnesium ions have a greater ionic radius than lithium ions.
 - D Magnesium ions have a greater charge than lithium ions.
- 8 Which one of the following would **not** reduce an acidified aqueous solution of potassium dichromate(VI)?
- A CH_3COOH
 - B Zn
 - C CH_3CHO
 - D $\text{Fe}^{2+}(\text{aq})$
- 9 Which one of the following would **not** react with aqueous silver nitrate to produce a precipitate that is soluble in concentrated aqueous ammonia?
- A CaBr_2
 - B $[\text{CoCl}_4]^{2-}$
 - C $(\text{CH}_3)_4\text{N}^+ \text{I}^-$
 - D CH_3COCl
- 10 In which one of the following reactions do two H^+ ions and one electron have to be added to the left-hand side in order to balance the equation?
- A $\text{CH}_3\text{CHO} \rightarrow \text{CH}_3\text{CH}_2\text{OH}$
 - B $\text{VO}^{2+} \rightarrow \text{V}^{3+} + \text{H}_2\text{O}$
 - C $\text{NO}_3^- \rightarrow \text{HNO}_2 + \text{H}_2\text{O}$
 - D $\text{HOCl} \rightarrow \frac{1}{2}\text{Cl}_2 + \text{H}_2\text{O}$

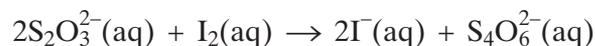
Turn over ►

- 11** Which one of the following solutions would **not** give a white precipitate when added to barium chloride solution?
- A** silver nitrate solution
 - B** dilute sulphuric acid
 - C** sodium sulphate solution
 - D** sodium nitrate solution
- 12** Which equation does **not** involve the reduction of a transition metal compound?
- A** $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
 - B** $\text{TiO}_2 + 2\text{C} + 2\text{Cl}_2 \rightarrow \text{TiCl}_4 + 2\text{CO}$
 - C** $\text{Cr}_2\text{O}_3 + 2\text{Al} \rightarrow 2\text{Cr} + \text{Al}_2\text{O}_3$
 - D** $\text{TiCl}_4 + 4\text{Na} \rightarrow \text{Ti} + 4\text{NaCl}$
- 13** The minimum mass of aluminium needed to displace 1000 g of iron from an excess of iron(III) oxide is
- A** 2067 g
 - B** 968 g
 - C** 484 g
 - D** 242 g

- 14** The percentage of copper in a copper(II) salt can be determined by using a thiosulphate titration. 0.305 g of a copper(II) salt was dissolved in water and added to an excess of potassium iodide solution, liberating iodine according to the following equation:



The iodine liberated required 24.5 cm³ of a 0.100 mol dm⁻³ solution of sodium thiosulphate:

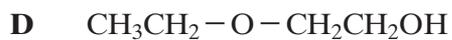
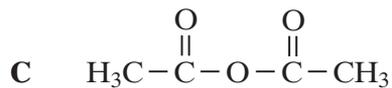
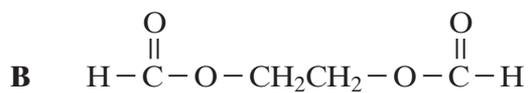


The percentage of copper, by mass, in the copper(II) salt is

- A** 64.2
B 51.0
C 48.4
D 25.5

Questions 15 and 16

Select the most appropriate compound from the list **A** to **D**.

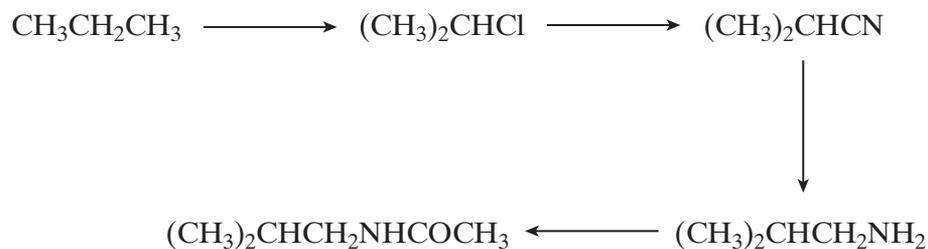


- 15** Which compound is formed by the reaction of an alcohol with epoxyethane?
- 16** Which compound is formed by the reaction of ethane-1,2-diol with an acid?

Turn over ►

Questions 17 and 18

Questions **17** and **18** refer to the following reaction sequence:



- 17** Which one of the following types of reaction is **not** involved in the above sequence?
- A** halogenation
 - B** acylation
 - C** reduction
 - D** oxidation
- 18** Which one of the following types of reaction mechanism is **not** involved in the above sequence?
- A** free-radical substitution
 - B** nucleophilic substitution
 - C** elimination
 - D** nucleophilic addition-elimination
- 19** Which one of the following statements about but-2-enal, $\text{CH}_3\text{CH}=\text{CHCHO}$, is **not** true?
- A** It has stereoisomers.
 - B** It shows a strong absorption in the infra-red at about 1700 cm^{-1} .
 - C** It will turn an acidified solution of potassium dichromate(VI) green.
 - D** It can be dehydrated by concentrated sulphuric acid.

20 Which one of the following has a major peak in its mass spectrum at $m/z = 57$?

- A propanone
- B 3-methylbutan-2-one
- C pentan-2-one
- D pentan-3-one

21 Which one of the following has a singlet peak in its proton n.m.r. spectrum?

- A ethyl propanoate
- B propyl methanoate
- C hexan-3-one
- D 2-chlorobutane

TURN OVER FOR THE NEXT QUESTION

Turn over ►

Multiple completion questions

For each of Questions 22 to 40, **one or more** of the options given may be correct. Select your answer by means of the following code.

A if (1), (2) and (3) only are correct.

B if (1) and (3) only are correct.

C if (2) and (4) only are correct.

D if (4) alone is correct.

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

Questions 22 to 24

Methanol can be synthesised in the gas phase from methane and steam as shown in the reactions below.

Reaction	Equation	$\Delta H^\ominus/\text{kJ mol}^{-1}$	$\Delta S^\ominus/\text{J K}^{-1}\text{mol}^{-1}$
P	$\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{CO}(\text{g})$	+206	+216
Q	$\text{CO}(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g})$	-91	-222
R	$\text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + \text{H}_2(\text{g})$	-41	-42
S	$\text{CO}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}) + \text{H}_2\text{O}(\text{g})$	-49	-180

22 In which of these reactions is a high equilibrium yield favoured by both low temperature and high pressure?

- (1) Reaction **P**
- (2) Reaction **Q**
- (3) Reaction **R**
- (4) Reaction **S**

23 Which of these reactions is/are feasible at 960 K?

- (1) Reaction **P**
- (2) Reaction **Q**
- (3) Reaction **R**
- (4) Reaction **S**

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

24 Hazards associated with this process include

- (1) methanol is a corrosive acid.
- (2) methane gas can form an explosive mixture with air.
- (3) carbon dioxide is a poisonous gas.
- (4) hydrogen is a flammable gas.

25 Correct statements include

- (1) the carbon–carbon bond length in cyclohexane is shorter than that in benzene.
- (2) the carbon–oxygen bond length in methanol is longer than that in methanal.
- (3) the C–C–C bond angle in benzene is smaller than that in cyclohexane.
- (4) the H–N–C bond angle in methylamine is greater than the H–O–C bond angle in methanol.

26 In which of the following species do three atoms lie in a straight line?

- (1) $[\text{Ag}(\text{NH}_3)_2]^+$
- (2) PF_5
- (3) XeF_4
- (4) $[\text{CoCl}_4]^{2-}$

Turn over ►

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

27 Which of the following is/are colourless?

- (1) iron(III) chloride solution
- (2) magnesium iodide solution
- (3) cobalt(II) sulphate solution
- (4) silver nitrate solution

28 In which of the following reactions does the oxidation state of an element decrease by 4 units or more?

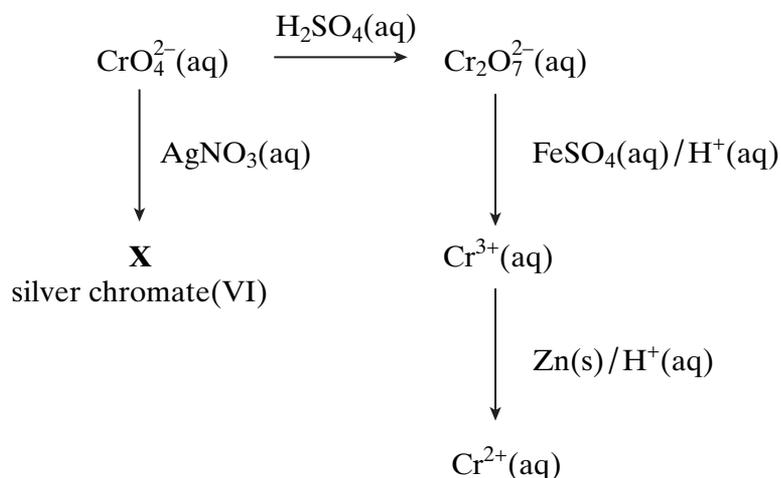
- (1) $\text{TiCl}_4 + 4\text{Na} \rightarrow \text{Ti} + 4\text{NaCl}$
- (2) $\text{MnO}_4^- + 4\text{H}^+ + 3\text{Fe}^{2+} \rightarrow \text{MnO}_2 + 3\text{Fe}^{3+} + 2\text{H}_2\text{O}$
- (3) $6\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 3\text{I}_2 + \text{S} + 4\text{H}_2\text{O}$
- (4) $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{V}^{2+} \rightarrow 2\text{Cr}^{3+} + 7\text{H}_2\text{O} + 6\text{V}^{3+}$

29 Which of the following statements is/are correct?

- (1) Argon is used as an inert atmosphere during the production of titanium.
- (2) One thousand moles of electrons would produce 9.0kg of aluminium during the electrolysis of aluminium oxide.
- (3) 8.4kg of carbon monoxide would produce 11.2kg of iron from an excess of Fe_2O_3
- (4) A method used to produce titanium is to heat titanium(IV) oxide with magnesium in an inert atmosphere.

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

30 Consider the reaction scheme shown below:



Which of the following statements is/are true?

- (1) Silver chromate(VI) has the formula Ag_2CrO_4
- (2) The minimum mass of zinc required to reduce 0.100 mol of Cr^{3+} to Cr^{2+} is 6.54 g
- (3) The conversion of CrO_4^{2-} into $\text{Cr}_2\text{O}_7^{2-}$ is not a redox reaction.
- (4) The equation $\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 9\text{Fe}^{2+} \rightarrow 9\text{Fe}^{3+} + \text{Cr}^{3+} + 7\text{H}_2\text{O}$ correctly describes the reduction of $\text{Cr}_2\text{O}_7^{2-}$ by acidified FeSO_4

31 Which of the following compounds has/have one or more lone pairs of electrons on the central atom?

- (1) BCl_3
- (2) XeF_4
- (3) PF_5
- (4) PCl_3

Turn over ►

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

32 A redox reaction occurs between which of the following?

- (1) Ba^{2+} and SO_4^{2-}
- (2) H^+ and CrO_4^{2-}
- (3) Mg^{2+} and OH^-
- (4) Fe^{3+} and I^-

33 Which of the following increase(s) down Group VII for the halogens and the halide ions?

- (1) the electronegativity of the halogen
- (2) the lattice dissociation energy of the sodium halide
- (3) the oxidising ability of the halogen in aqueous solution
- (4) the strength of the halide ion as a reducing agent in aqueous solution

34 Amphoteric hydroxides include

- (1) $\text{Al}(\text{OH})_3$
- (2) $\text{Be}(\text{OH})_2$
- (3) $\text{Cr}(\text{OH})_3$
- (4) $\text{Ca}(\text{OH})_2$

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

35 Ethane-1,2-diol could be obtained from

- (1) oxidation of ethanedial by acidified potassium dichromate(VI).
- (2) reaction of an excess of water with epoxyethane.
- (3) acid-catalysed addition of water to ethene.
- (4) reaction of bromine with ethene followed by alkaline hydrolysis.

36 Which of the following statements is/are true?

- (1) Water has a singlet peak in its proton n.m.r. spectrum.
- (2) Propanone has a major fragment peak at $m/z = 43$ in its mass spectrum.
- (3) Water has an absorption at about 3350 cm^{-1} in its infra-red spectrum.
- (4) Water and ethane-1,2-diol cannot be distinguished in their infra-red spectra above 1600 cm^{-1} .

37 Which of the following involve(s) free radicals?

- (1) reaction of chlorine with hexane to make a chlorohexane
- (2) fragmentation of butanone in the mass spectrometer
- (3) heating of $\text{C}_{16}\text{H}_{34}$ to make C_8H_{18} and C_2H_4
- (4) production of nylon 6,6 by polymerisation

Turn over ►

Directions summarised			
A	B	C	D
(1), (2) and (3) only correct	(1) and (3) only correct	(2) and (4) only correct	(4) only correct

- 38** An excess of methane is reacted with chlorine in the presence of ultra-violet light. The principal organic product of the reaction has
- (1) permanent dipole–dipole forces between molecules.
 - (2) van der Waals' forces between molecules.
 - (3) covalent bonds between atoms.
 - (4) hydrogen bonds between molecules.
- 39** Correct statements about 2-bromo-2-methylpropane include
- (1) it is a secondary haloalkane.
 - (2) it exhibits hydrogen bonding between molecules.
 - (3) it has an M_r of 138.
 - (4) it forms 2-methylpropene when heated with ethanolic NaOH.
- 40** Which of the following pairs react(s) to form more than one organic product?
- (1) $\text{CH}_4 + \text{Cl}_2$
 - (2) $\text{CH}_3\text{CH}_2\text{Br} + \text{NH}_3$
 - (3) $\text{CH}_3\text{CHBrCH}_3 + \text{NaOH}$
 - (4) $\text{CH}_3\text{COCl} + \text{NH}_3$

END OF QUESTIONS