Dalziel High School
Chemistry Department
1998 CSYS

CERTIFICATE OF SIXTH YEAR STUDIES 1998

MONDAY, 18 MAY
9.30 AM – 12.00 NOON

CHEMISTRY
Paper

All questions should be attempted.

Necessary data will be found in the Chemistry (Revised) Higher Grade and Certificate of Sixth Year Studies Data Booklet (1992 edition) which is provided.

SCOTTISH QUALIFICATIONS AUTHORITY

MCB 0500/301 6/5226

1. $25\,cm^3$ of sodium hydroxide solution requires $30\,cm^3$ of $1\ mol\ l^{-1}$ sulphuric acid for complete neutralisation.

The number of moles of sodium hydroxide neutralised are

A 0·03

B 0·06

C 1·20

D 2·40.

2. A titration was carried out using potassium carbonate solution and hydrochloric acid. The **most** suitable indicator for this titration is

	INDICATOR	pH of Colour Change
A	Universal	4·0 – 11·0
B	Phenolphthalein	8·0 – 9·8
C	Bromothymol blue	6·0 – 7·6
D	Methyl orange	3·0 – 4·4

3. The reaction between copper metal and silver(I) nitrate solution can be written as follows.

$$Cu(s) + 2AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2Ag(s)$$

The addition of excess copper metal to $100\,cm^3$ of silver(I) nitrate solution produces a precipitate of 0·108 g of silver metal.

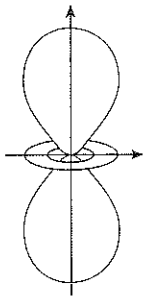
What quantity of silver(I) nitrate solid was used to make up the $100\,cm^3$ of silver(I) nitrate solution?

A 0·002 moles

B 0·34 g

C 0·001 moles

D 0·017 g

4. 

The above is a diagrammatical representation of

A any p-orbital

B a specific p-orbital

C any d-orbital

D a specific d-orbital.

5. $C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H^\circ = -394\,kJ\,mol^{-1}$

$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell) \qquad \Delta H^\circ = -286\,kJ\,mol^{-1}$

$C_6H_{14}(\ell) + 9\frac{1}{2}O_2(g) \rightarrow 6CO_2(g) + 7H_2O(\ell)$

$\Delta H^\circ = -4160\,kJ\,mol^{-1}$

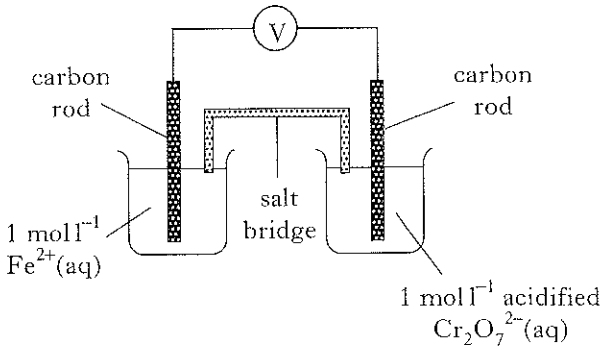
Using the above data, the standard enthalpy of formation of hexane is

A $-3480\,kJ\ mol^{-1}$

B $+3480\,kJ\ mol^{-1}$

C $-206\,kJ\ mol^{-1}$

D $+206\,kJ\ mol^{-1}$.

6. 

In the electrochemical cell shown above, operating under standard conditions, which of the following would give the emf of the cell?

A $-0·77 + 1·33\,V$

B $-1·33 + 0·77\,V$

C $(6 \times -0·77) + 1·33\,V$

D $-0·41 + 1·33\,V$

7. 1·60 g of a metal sulphate were dissolved in water. Addition of excess barium chloride solution resulted in the precipitation of 2·33 g of barium sulphate.

Given that the relative atomic mass of barium is 137, the original substance was

A copper (II) sulphate

B magnesium sulphate

C sodium sulphate

D calcium sulphate.

8. A solid dissolves endothermically at 298K.

The values for ΔH° and ΔS° could be

	ΔH°/kJ mol^{-1}	ΔS°/JK^{-1} mol^{-1}
A	−210	+32
B	+210	+32
C	−32	+210
D	+32	+210

9. In which of the following changes will there be an increase in entropy?

A Phenylethene → poly (phenylethene)

B Combustion of ethanol

C $CO_2(g) \rightarrow CO_2(s)$

D Hydrogenation of ethene

10. Which of the following salts shows most ionic character?

A K^+Cl^-

B Na^+Br^-

C Li^+I^-

D Na^+Cl^-

11. The standard enthalpy of formation of sodium chloride is represented as

A $Na^+(g) + Cl^-(g) \rightarrow Na^+Cl^-(g)$

B $Na^+(g) + Cl^-(g) \rightarrow Na^+Cl^-(s)$

C $Na(s) + Cl(g) \rightarrow Na^+Cl^-(s)$

D $Na(s) + \frac{1}{2}Cl_2(g) \rightarrow Na^+Cl^-(s)$

12. For which of the following reactions would the value of $\Delta G^\circ - \Delta H^\circ$ be approximately zero?

A $C(s) + H_2O(g) \rightarrow CO(g) + H_2(g)$

B $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

C $Cu^{2+}(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + Cu(s)$

D $Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$

13. Which of the following changes would cause the most beneficial reduction in the production of greenhouse gases?

A The fitting of catalytic converters to all cars

B The withdrawal of all aerosols

C Increased use of nuclear power to generate electricity

D The fitting of flue-gas desulphurisation plants to all coal-fired power stations

14. In which of the following molecules would you expect to find the smallest angle between two adjacent covalent bonds?

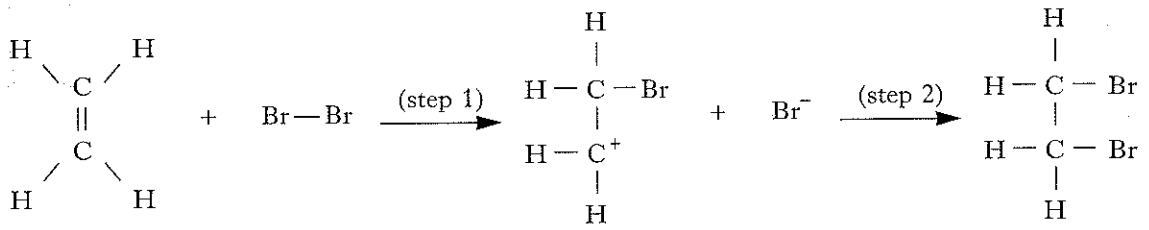
A BF_3

B CCl_4

C NH_3

D H_2O

15.



The two steps in the mechanism shown could be described as

A ethene acting as an electrophile and Br^- acting as an electrophile

B ethene acting as an electrophile and Br^- acting as a nucleophile

C ethene acting as a nucleophile and Br^- acting as a nucleophile

D homolytic fission of the Br_2 followed by Br^- acting as a nucleophile.

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16. $2X + 3Y_2 \longrightarrow$ products

A correct statement which can be made about the above reaction is that

A the overall order of the reaction is 5

B the rate expression cannot be predicted

C the reaction order with respect to X is 2

D the reaction will be slow due to the number of particles colliding.

17. Which of the following will be oxidised by silver(I) nitrate dissolved in dilute ammonia solution (ammoniacal silver(I) nitrate)?

A CH_3COCH_3

B CH_3CHO

C CH_3OH

D $(CH_3)_2CHOH$

18. In which of the following compounds does hydrogen bonding occur?

A CH_3I

B CH_3CH_2CHO

C CH_3OCH_3

D CH_3OH

19. The reaction between propanone and 2, 4-dinitrophenylhydrazine is classed as

A condensation

B addition

C substitution

D oxidation.

20. $AgCl(s) \longrightarrow Ag^+(aq) + Cl^-(aq)$

The solubility product (K_s) for silver chloride is given by the expression

$$K_s = [Ag^+(aq)]\,[Cl^-(aq)]$$

If $K_s = 1{\cdot}8 \times 10^{-10}\ mol^2 l^{-2}$ at 25 °C, what is the solubility of silver chloride at 25 °C, given that the formula mass of AgCl is 143·5?

A $1{\cdot}8 \times 10^{-10} \times 143{\cdot}5\,g\,l^{-1}$

B $1{\cdot}34 \times 10^{-5} \times 143{\cdot}5\,g\,l^{-1}$

C $9{\cdot}0 \times 10^{-6} \times 143{\cdot}5\,g\,l^{-1}$

D $\dfrac{1{\cdot}8 \times 10^{-10}}{143{\cdot}5}\,g\,l^{-1}$

21. Which of the following contains approximately 6×10^{23} molecules?

A 16 g oxygen

B 40 g neon

C 58·5 g sodium chloride

D 160 g bromine

22. $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

Removing the sulphur trioxide produced in the above system will

A decrease the concentration of SO_2 only

B decrease the concentration of SO_2 and O_2

C decrease the value of the equilibrium constant

D increase the value of the equilibrium constant.

[Turn over

23. The degree of dissociation of a base is given by the constant K_b.

BASE	K_b/mol l^{-1}
ammonia	$1{\cdot}8 \times 10^{-5}$
methylamine	$4{\cdot}5 \times 10^{-4}$
phenylamine	$4{\cdot}3 \times 10^{-10}$
phenylmethylamine	$2{\cdot}4 \times 10^{-5}$

20 cm^3 of 0·1 mol l^{-1} solutions of each of the above bases were neutralised with 0·1 mol l^{-1} hydrochloric acid and the pH of the resulting solutions measured.

Which base would have given the neutralised solution with the highest pH?

A Ammonia

B Methylamine

C Phenylamine

D Phenylmethylamine

24. $P + Q \rightleftharpoons R + S$

At 298 K the equilibrium constant for this reaction is $1{\cdot}2 \times 10^{10}$.

Which of the following is true?

A Increasing the concentration of P will not change the equilibrium constant.

B The value of ΔG^o is very positive.

C Adding a catalyst will change the equilibrium constant.

D The value of ΔS^o is very positive.

25. 5·0 cm^3 of a solution of hydrochloric acid was diluted to exactly 250 cm^3 with water. The pH of this diluted solution was 2·0.

The concentration of the original undiluted solution was

A 0·02 mol l^{-1}

B 0·04 mol l^{-1}

C 0·40 mol l^{-1}

D 0·50 mol l^{-1}.

26. Which of the following statements is not always true for aqueous solutions at 298 K?

A $[H^+] = [OH^-] = 10^{-7}$ mol l^{-1}

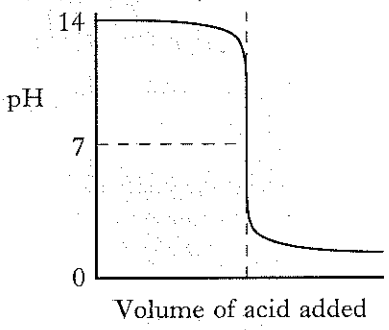
B $K_W = 10^{-14}$ mol^2 l^{-2}

C $[H^+]\,[OH^-] = 10^{-14}$ mol^2 l^{-2}

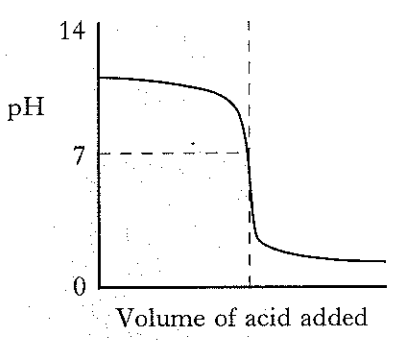
D $pH = -\log_{10}[H^+]$

27. Which one of the following represents the results obtained when a weak acid is added to a strong alkali and the pH is measured at intervals using a pH meter?

A



B



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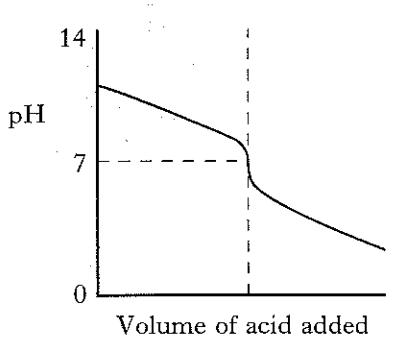
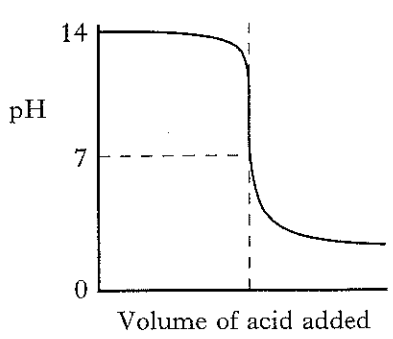


D



28. 5 cm^3 of a 0·01 mol l^{-1} solution of hydrochloric acid was added to each of the following mixtures. The concentration of all the solutions is 0·1 mol l^{-1}.

In which case would there be the least change in pH?

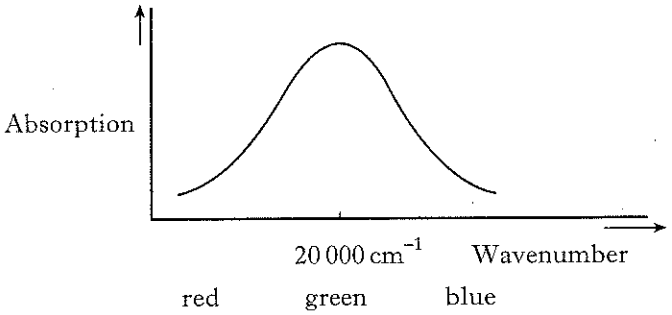
A 50 cm^3 HCl(aq) + 50 cm^3 NaCl(aq)

B 50 cm^3 NaCl(aq) + 50 cm^3 NH_4Cl(aq)

C 50 cm^3 NH_4Cl(aq) + 50 cm^3 NH_3(aq)

D 50 cm^3 NH_3(aq) + 50 cm^3 HCl(aq)

Refer to this absorption spectrum of $Ti(H_2O)_6^{3+}$ for Questions 29 and 30.



29. The colour which would be observed is

A red

B green

C blue

D purple.

30. The colour is caused by

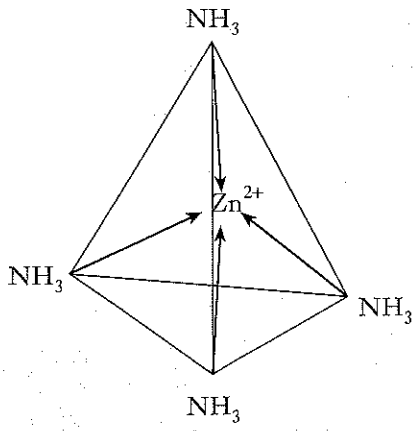
A d→d transitions

B charge transfer

C excited electrons dropping to the ground state

D electrons absorbing energy to jump from the first to the second shell.

31. Consider the complex ion shown below.



Which of the following statements about it is true?

A The coordination number is 2+.

B The arrangement of ligands is triangular.

C The complex ion has no overall charge.

D The ligands attach through electron pairs.

32. A complex ion with the name hexaamminetitanium(III) will have the formula

A $Ti(CH_3NH_2)_6^{3+}$

B $Ti(NH_3)_6^{3+}$

C $Ti(NH_4^+)_6^{3-}$

D $Ti(NH_3)_6^{3-}$

33. The formulae of two complex salts of cobalt are given below.

$Co(NH_3)Cl_3$ I $K_4Co(CN)_6$ II

The oxidation state of cobalt is

A +3 in I and +2 in II

B –3 in I and +2 in II

C –3 in I and –4 in II

D +3 in I and –4 in II.

34. If the wavelength of visible light from a tunable laser is increased

A the wavenumber increases

B the velocity increases

C the frequency increases

D the colour changes towards red.

35. Which of the following is the unit for the rate of a chemical reaction?

A $mol\,l^{-1}s^{-1}$

B $mol\,l^{-1}$

C $s\ mol^{-1}$

D s^{-1}

36. The data below show the energy required to vaporise the following solids.

sodium chloride	771 kJ mol^{-1}
ice	50 kJ mol^{-1}
sodium	109 kJ mol^{-1}

From this information it can be concluded that

A ionic bonds are stronger than covalent bonds

B ionic bonds are stronger than metallic bonds

C metallic bonds are stronger than covalent bonds

D covalent bonds are weaker than metallic and ionic bonds.

37. An indicator (H_2A) is a weak acid, and undergoes a two-stage ionisation.

$$\underset{\text{yellow}}{H_2A} \overset{\text{stage 1}}{\rightleftharpoons} \underset{\text{blue}}{HA^- + H^+} \overset{\text{stage 2}}{\rightleftharpoons} \underset{\text{green}}{A^{2-} + 2H^+}$$

The colours of the species are shown. The dissociation constants for the two ionisations are given by

$pK_1 = 3{\cdot}5$ and $pK_2 = 5{\cdot}9$.

Given that for an indicator pK = pH at the point where the colour change occurs, the indicator will be

A yellow in a solution of pH 3, and green in a solution of pH 5

B blue in a solution of pH 3, and green in a solution of pH 5

C yellow in a solution of pH 3, and blue in a solution of pH 5

D blue in a solution of pH 3, and blue in a solution of pH 5.

38. Which of the following is produced commercially by reduction with carbon?

A Gold

B Iron

C Aluminium

D Titanium

39. Which one of the following compounds exists as linear molecules?

A CH_4

B C_2H_2

C C_2H_4

D C_2H_6

40. Salts having the empirical formula $CrCl_3(H_2O)_6$ have been isolated in three isomeric forms. Analysis of one isomer showed one third of the total chlorine content was precipitated as silver(I) chloride by the addition of excess silver(I) nitrate solution.

The formula of the isomer is

A $[Cr(H_2O)_6]^{3+}(Cl^-)_3$

B $[Cr(H_2O)_5Cl]^{2+}(Cl^-)_2.H_2O$

C $[Cr(H_2O)_4Cl_2]^+Cl^-.2H_2O$

D $[Cr(H_2O)_3Cl_3].3H_2O$

41. The boxes in the grid below show some electron arrangements.

Note: [Ar] represents the electron arrangement of argon.

A $1s^2\ 2s^2\ 2p^6\ 3s^1$	B $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	C [Ar] $4s^2\ 3d^5$
D [Ar] $4s^2\ 3d^{10}\ 4p^6$	E $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	F [Ar] $4s^2\ 3d^{10}\ 4p^5$

Identify the electron arrangement

(*a*) of Br^-

(*b*) of a transition metal.

42. The boxes in the grid below show various ions present in solutions of concentration 1 mol l^{-1}.

A $I^-(aq)$	B $Ag^+(aq)$	C $Cu^{2+}(aq)$
D $Fe^{2+}(aq)$	E $Cl^-(aq)$	F $Sn^{2+}(aq)$

Identify the **two** ions which

(*a*) will oxidise sulphite ions in 1 mol l^{-1} solution

(*b*) could theoretically react together both in a redox reaction and in a precipitation reaction.

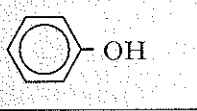
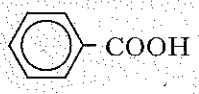
43. The boxes in the grid below contain certain metal ions.

A	B	C
$Sc^{3+}(g)$	$Ca^{2+}(g)$	$Ti^{4+}(g)$
D	**E**	**F**
$Mn^{2+}(g)$	$Fe^{3+}(g)$	$Zn^{2+}(g)$

Species with unpaired electrons are said to be paramagnetic.

Identify the paramagnetic species.

44. The boxes in the grid below contain the formulae for certain organic species.

A	B	C
$CH_3CH(OH)CH_3$	$CH_3C(CH_3)(OH)CH_3$	
D	**E**	**F**
$CH_3CH_2-O-CH_2CH_3$	$CH_3CH_2COCH_3$	

Identify

(*a*) **two** species which will produce an acidic solution if added to water

(*b*) the species which on oxidation will produce a compound belonging to the same homologous series as **E**.

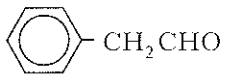
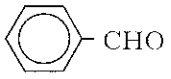
[Turn over

45. Some aldehydes can undergo the Cannizzaro reaction which can be represented by the following equation.

$$2\,X - CHO + H_2O \rightarrow X - COOH + X - CH_2OH$$

An aldehyde will react in this way provided that "X" does **not** contain a $- CH_2 -$ group attached to the functional group.

The boxes in the grid below contain the formulae or names of certain aldehydes.

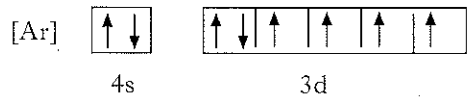
A 	B butanal	C 
D methanal	E C_2H_5CHO	F 3-methylbutanal

Identify the aldehyde(s) capable of undergoing the Cannizzaro reaction.

[END OF QUESTION PAPER]

Marks

1. The electronic configuration of an atom of iron may be represented by



(*a*) How does this arrangement for the 3d electrons follow Hund's rule of maximum multiplicity? **1**

(*b*) Give a similar type of arrangement to represent the electronic configuration for an iron(III) ion. **1**

(*c*) In the complex ion, hexacyanoferrate(III), two of the 3d orbitals are at a higher energy level than the other three.

How many unpaired 3d electrons are there in the complex ion? **1**

(3)

2. Commercial bleaches contain the hypochlorite ion (OCl^-) as the bleaching agent. The concentration of the hypochlorite ion can be determined by adding a sample of the bleach to excess potassium iodide and ethanoic acid. The iodine released is determined by titrating against standard sodium thiosulphate solution using starch indicator.

The relevant equations are:

$$OCl^-(aq) + 2H^+(aq) + 2I^-(aq) \longrightarrow I_2(aq) + Cl^-(aq) + H_2O(\ell)$$

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

In an investigation, $10{\cdot}0\,cm^3$ of a commercial bleach solution was diluted to $250\,cm^3$ in a standard flask. $25{\cdot}0\,cm^3$ samples were pipetted into conical flasks containing excess potassium iodide and ethanoic acid. Each sample was titrated against $0{\cdot}10\ mol\,l^{-1}$ sodium thiosulphate using starch as an indicator. The results of the titration are given below.

Burette Reading	Titre 1/cm^3	Titre 2/cm^3	Titre 3/cm^3
Initial	0·00	14·00	27·00
Final	12·90	26·55	39·45

(*a*) What colour change is observed at the end point? **1**

(*b*) What is the function of the ethanoic acid? **1**

(*c*) What volume of the sodium thiosulphate solution should be used as the titration value in the calculation? **1**

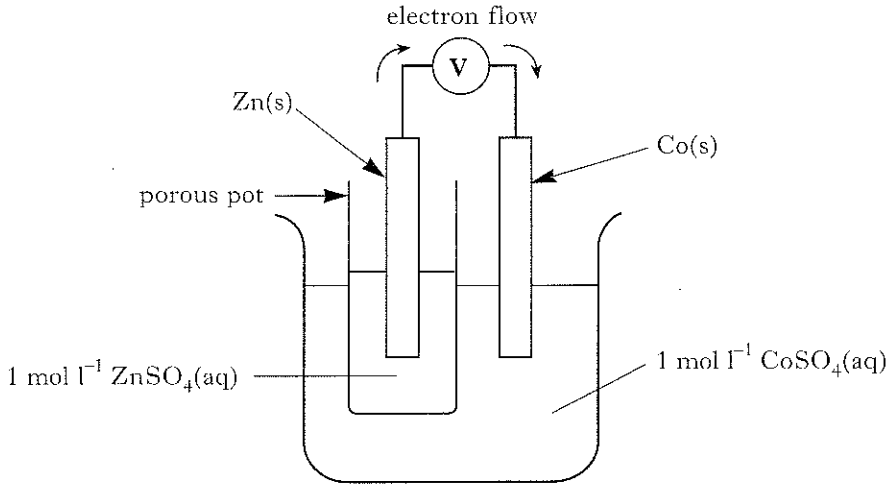
(*d*) Calculate the number of moles of hypochlorite ions in $25{\cdot}0\,cm^3$ of the diluted bleach. **2**

(*e*) Calculate the concentration in $mol\,l^{-1}$ of hypochlorite ions in the commercial bleach. **2**

(7)

Marks

3.



When the above cell is operating under standard conditions, the reading on the voltmeter is 0·48 volts.

(*a*) Calculate the standard reduction potential for the half reaction

$$Co^{2+}(aq) + 2e \longrightarrow Co(s)$$ **1**

(*b*) Calculate the standard free energy change for this cell. **3**

(4)

[Turn over

Marks

4. Consider the reaction

$$NO_2(g) + CO(g) \rightarrow CO_2(g) + NO(g)$$

for which the rate equation has been shown by experiment to be

$$\text{Rate} = k\,[NO_2]^2$$

The first stage of this two stage reaction is the rate determining step (r.d.s.).

The equation for this stage is

$$NO_2(g) + NO_2(g) \rightarrow NO_3(g) + NO(g)$$

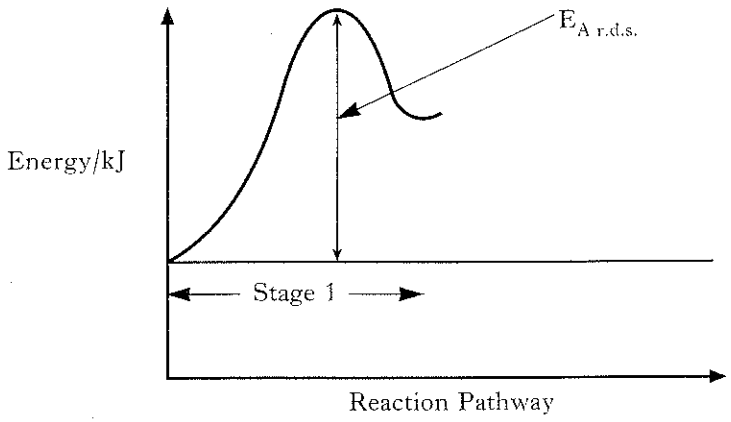
(*a*) Write the equation for the second stage which completes the reaction. **1**

The table gives kinetic data for the above reaction at constant temperature.

Relative $[NO_2]$	Relative [CO]	Relative Rate
1	1	1
2	1	*x*
2	2	*y*

(*b*) Determine the values for *x* and *y* in the table. **2**

The diagram below (not to scale) shows the energy change for the first stage of the reaction.
The enthalpy change, $\Delta H°$, for the overall reaction is –226 kJ.



(*c*) Copy the diagram into your answer book and complete it, with labels, to show:

(i) the completed energy diagram for the second stage; **1**

(ii) the activation energy, E_A, for the second stage; **1**

(iii) $\Delta H°$ for the overall reaction. **1**

(6)

Marks

5. One of the reactions in the production of a nuclear fuel from U_3O_8 is

$$UO_2(s) + 4HF(g) \rightarrow UF_4(s) + 2H_2O(g) \quad \Delta H^\circ = -244\,kJ$$

The data in the table below refer to the substances at 298 K.

Substance	$S^\circ/JK^{-1}\,mol^{-1}$
$UO_2(s)$	77
$HF(g)$	174
$UF_4(s)$	152
$H_2O(g)$	189

(*a*) Use the data to calculate the entropy change for the reaction at 298 K. 2

(*b*) Determine by calculation whether the reaction is feasible at 298 K. 3

(5)

6. SF_4 is a useful fluorinating agent capable of converting the carbonyl group $\left(\rangle C = O\right)$ in organic compounds to the $\rangle CF_2$ group without affecting other functional groups.

In the SF_4 molecule there are 4 bonding pairs and 1 non-bonding pair of electrons.

(*a*) Draw the shape of the SF_4 molecule. 1

(*b*) Draw the structural formula and give the name of the compound formed when 3-methylbutanone is reacted with SF_4. 2

(3)

[Turn over

Marks

7. Grignard reagents have the general formula RMgX, where R = an alkyl group and X = a halogen atom. Preparation involves reacting an alkyl halide with magnesium in dry ethoxyethane (an ether) to prevent hydrolysis occurring. The Grignard reagent methyl magnesium iodide, CH_3MgI, was reacted with carbon dioxide

$$CH_3MgI + CO_2 \rightarrow CH_3COOMgI$$

followed by hydrolysis with dilute sulphuric acid

$$CH_3COOMgI + H_2O \rightarrow \text{"Y"} + Mg(OH)I$$

The organic product "Y" dissolves in the ether and the magnesium compound dissolves in the dilute acid, giving two immiscible layers.

(*a*) Suggest how "Y" can be isolated. **1**

(*b*) Give **one** advantage and **one** disadvantage of using an ether as a solvent for chemical reactions. **2**

The infra-red spectrum for a pure sample of "Y" shows a broad absorption band in the range 3500–2500 cm^{-1} and at least one other characteristic absorption band, apart from those due to C–H bonds.

(*c*) Use the information above and page 15 in your Data Booklet to

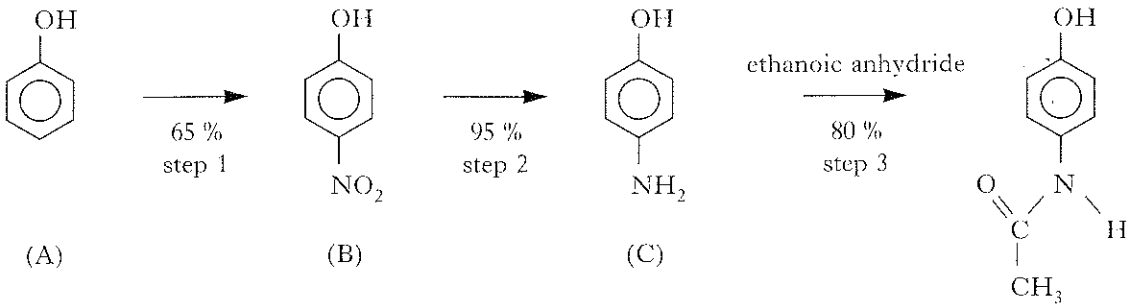
(i) identify "Y", and

(ii) suggest the wavenumber range of the other main absorption band. **2**

(*d*) Explain why, in a Grignard reagent, the methyl group acts as a nucleophile, whereas in methyl iodide, the methyl group acts as an electrophile. **2**

(7)

8. A synthetic route to the analgesic compound (D) is shown below. The percentage yield for each step is given below each arrow.



(A) (B) (C) (D)

(*a*) Name reactant (A). **1**

(*b*) What nitrating mixture would be used to react with (A) in step 1? **1**

(*c*) Which type of reaction takes place in step 2? **1**

(*d*) Calculate the mass of analgesic which would be formed starting from 43·6 g of compound (C). **3**

(*e*) Draw the structure of the organic compound formed when compound (C) is reacted with

(i) dilute hydrochloric acid, **1**

(ii) sodium hydroxide solution. **1**

(8)

Marks

9. $250\,cm^3$ of sulphurous acid solution was prepared by dissolving 1·6 g of sulphur dioxide in water at 298 K.

   (*a*) Calculate the concentration of the acid solution in $mol\,l^{-1}$. 2

   (*b*) Using your answer to (*a*) and page 14 of your Data Booklet, calculate the pH of the acid solution. 3

   (*c*) Why is this acid solution unsuitable for use as a primary standard? 1

   (*d*) If this acid solution is standardised using a strong alkali, what will be the approximate pH range of the indicator needed for the titration? 1

   (7)

10. The recycling of scrap nickel to obtain the pure metal involves the production of the gaseous complex, $Ni(CO)_4$. The complex forms when carbon monoxide is passed over the heated scrap. To separate the pure nickel, the complex is passed over nickel pellets which are at a higher temperature. Carbon monoxide is recycled.

    The data in the table below relate to the carbonyl complex.

Temperature/K	Complex
248	Melts
316	Boils
473	Decomposes

   (*a*) Suggest

   (i) a suitable temperature for the production of $Ni(CO)_4$, 1

   (ii) the minimum temperature to which the nickel pellets must be heated. 1

   (*b*) What is the oxidation number (state) of nickel in the complex? 1

   (3)

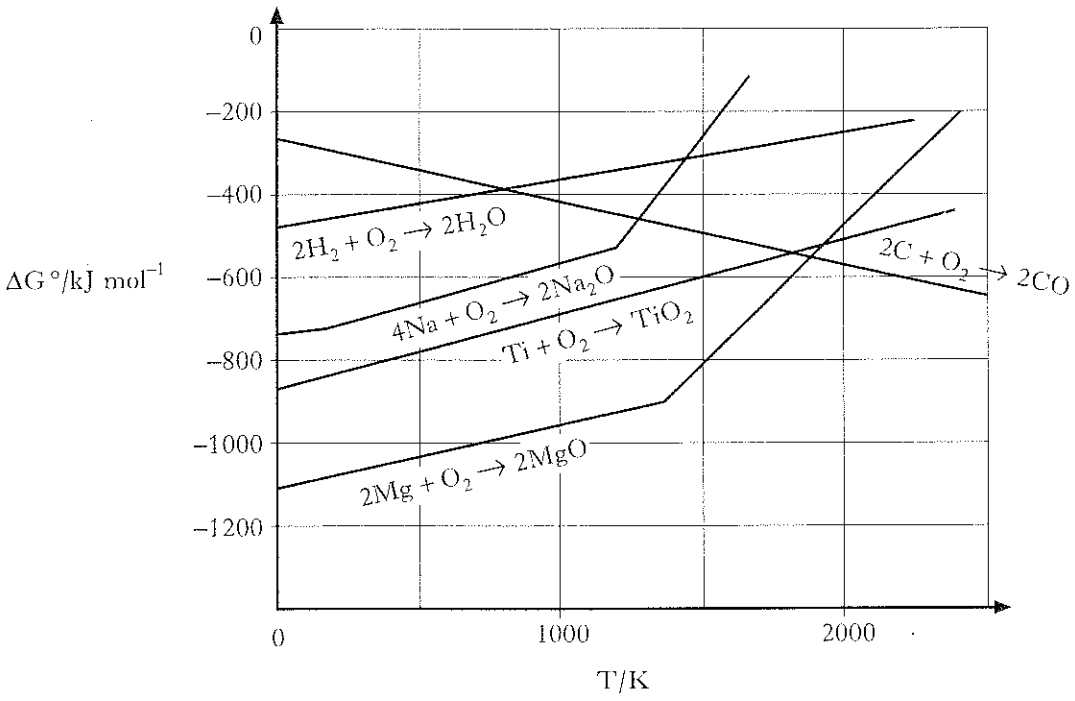
[Turn over

Marks

11. Titanium is the fourth most abundant metal in the Earth's crust. It is stronger than steel, is resistant to corrosion and its alloys are used in rocket and jet engines. Future use might be in the manufacture of car parts.

(*a*) With reference to the Data Booklet, suggest an additional reason why titanium is preferable to steel for the uses described above. **1**

The Ellingham diagram below indicates that it is feasible to reduce rutile (TiO_2), the common ore of titanium, with carbon.



(*b*) (i) State a range of temperature at which this reduction can take place. **1**

(ii) Give a reason why carbon on its own is **not** used for this reduction. **1**

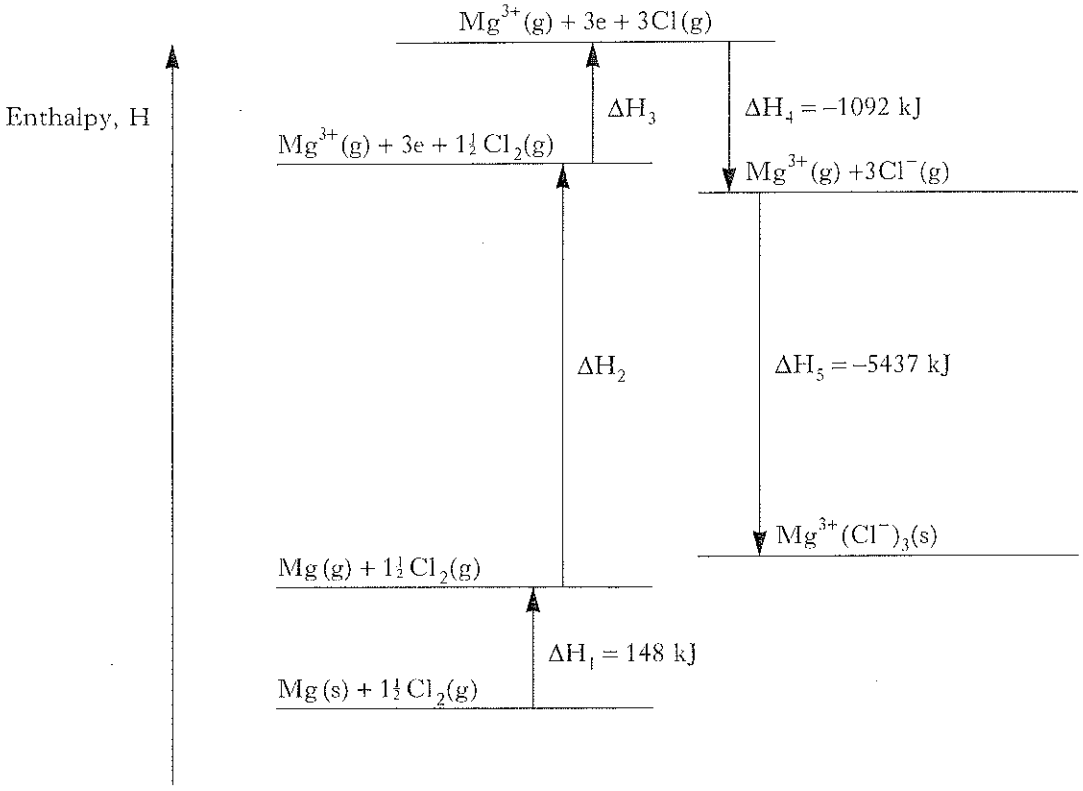
(*c*) Name one other substance shown on the diagram that could reduce rutile. **1**

(*d*) From your knowledge of the actual process by which titanium is extracted from rutile, suggest a reason why it would be uneconomical at present to use titanium for the manufacture of car parts. **1**

(5)

Marks

12. The diagram below (which is not drawn to scale) shows the enthalpy changes for the formation of the hypothetical compound, $MgCl_3$ from its elements in their standard states.



(*a*) What names are given to the enthalpy changes represented by

(i) ΔH_1, **1**

(ii) ΔH_5? **1**

(*b*) Write down values for the enthalpy changes represented by

(i) ΔH_2, **1**

(ii) ΔH_3. **1**

(*c*) Calculate the standard enthalpy of formation of $MgCl_3$. **1**

(5)

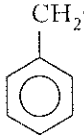
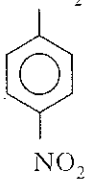
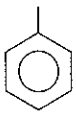
[Turn over

13. The oxidation of alcohols to carbonyl compounds is a fundamental transformation in organic chemistry. A great number of oxidising agents can effect the conversion of an alcohol to a carbonyl compound. However, the susceptibility of aldehydes to further oxidation narrows the choice of reagent for the oxidation of primary alcohols to aldehydes in good yield. Hexamethylenetetramine-bromine, an easily handled solid reagent, allows for conversion of primary and secondary alcohols into aldehydes and ketones respectively. These reactions share the virtues of ease of operation, simplicity of product isolation, formation of products in high yields and the absence of side reactions.

The hexamethylenetetramine-bromine reagent is readily prepared by adding bromine to a chloroform solution of the amine. The solid reagent is very stable at room temperature and has no offensive odour of bromine or amine.

As shown in the table below, secondary alcohols are oxidised more easily than primary ones using this complex, but primary aromatic alcohols can be readily oxidised to aldehydes in good yields. The oxidation rate decreases considerably in aromatic alcohols when there is an electron-withdrawing group on the benzene ring.

In conclusion, hexamethylenetetramine-bromine is an oxidant which promises to be economical, convenient and efficient for a wide variety of cases.

Entry	Reactant	Reaction Time/hour
1	$CH_3CH_2CH_2CH_2OH$	3·0
2		1·3
3		3·1
4	$CH_3CH_2CH(OH)CH_3$	0·3
5		0·7
6	cyclopentanol	0·5
7	cyclohexanol	0·2
8	cyclooctanol	0·05

Marks

(*a*) Name a reagent, other than hexamethylenetetramine-bromine, which can oxidise both primary and secondary alcohols. **1**

(*b*) State,

(i) the main advantage **1**

(ii) two other reasons **2**

for using hexamethylenetetramine-bromine to oxidise primary alcohols rather than using other oxidising agents.

(*c*) Give the numbers of the two entries from the table which can be compared to show that hexamethylenetetramine-bromine oxidises secondary alcohols more readily than primary alcohols. **1**

(*d*) From the information in the table, state,

(i) which group on the benzene ring has an electron-withdrawing effect, and **1**

(ii) a trend that can be deduced for the oxidation of cycloalkanols. **1**

(7)

[END OF QUESTION PAPER]