SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures										Letter
Words										

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2001

CHEMISTRY

Written examination 2

Wednesday 14 November 2001

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	8	8	56
			Total 76

Materials
- Question and answer book of 19 pages, with a detachable data sheet in the centrefold.
- Working space is provided throughout this book.
- Answer sheet for multiple-choice questions.
- At least one pencil, and an eraser.
- One approved calculator (memory cleared) and/or one scientific calculator.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided on this book.
- Check that your **name** and **student number**, as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

SECTION A – Multiple-choice questions

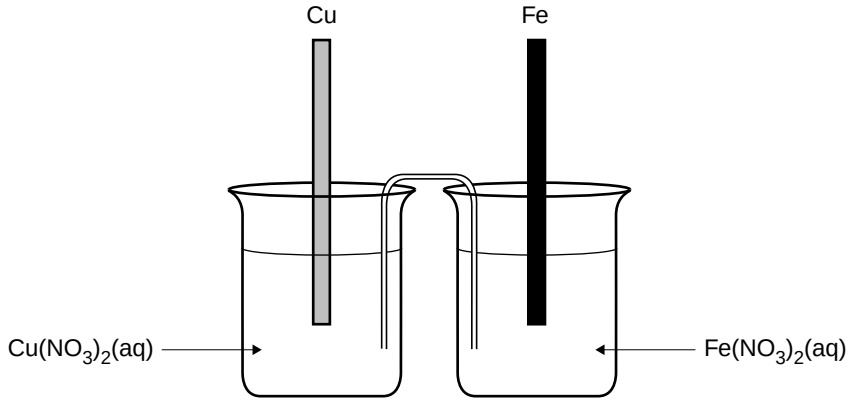
Instructions for Section A

Answer **all** questions on the answer sheet provided for multiple-choice questions.

A correct answer scores 1, an incorrect answer scores 0. No mark will be given if more than one answer is completed for any question.

Section A is worth approximately 26 per cent of the marks available. You should spend approximately 24 minutes on this section.

Use the experimental arrangement below to answer Questions 1 and 2.



The experimental arrangement shows a

- copper rod dipping into a 1.0 M solution of $Cu(NO_3)_2(aq)$
- iron rod dipping into a 1.0 M solution of $Fe(NO_3)_2(aq)$

The solutions are connected to each other with a salt bridge consisting of an inverted U-tube containing ammonium nitrate solution.

Question 1

When the appropriate electrodes are connected, the purpose of the salt bridge is to

A. enable current to flow between two half cells by allowing electrons to flow through the salt bridge.

B. provide ammonium and nitrate ions to each half cell to maintain a constant pH in each half cell.

C. enable current to flow between two half cells by allowing ions to flow through the salt bridge.

D. provide ammonium and nitrate ions for the electrode reactions in each half cell.

Question 2

The copper and iron rods are connected with a wire and an electric current is observed to flow through the wire.

The iron rod will be

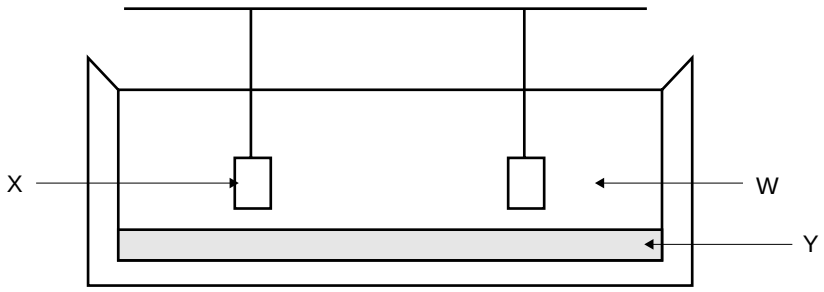
A. positive and the reaction occurring at the iron rod is $Fe^{2+} + 2e^- \rightarrow Fe$

B. positive and the reaction occurring at the iron rod is $Fe \rightarrow Fe^{2+} + 2e^-$

C. negative and the reaction occurring at the iron rod is $Fe^{2+} + 2e^- \rightarrow Fe$

D. negative and the reaction occurring at the iron rod is $Fe \rightarrow Fe^{2+} + 2e^-$

Use the following diagram and the process it shows to answer Questions 3, 4 and 5.



The diagram represents an industrial cell designed for the electrolytic production of aluminium metal. The arrow Y points to the molten aluminium that is produced in the pot.

Question 3

The arrow W points to

A. molten Al_2O_3

B. Al_2O_3 in molten NaCl

C. Al_2O_3 in molten Na_3AlF_6

D. Al_2O_3 in molten NaF

Question 4

The arrow X points to a

A. carbon anode.

B. steel anode.

C. carbon cathode.

D. steel cathode.

Question 5

The net or **overall** cell reaction (state symbols are not shown) is

A. $2Al_2O_3 \rightarrow 4Al + 3O_2$

B. $Al^{3+} + 3e^- \rightarrow Al$

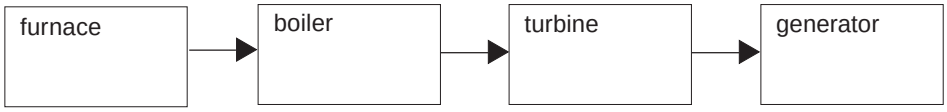
C. $2AlF_3 \rightarrow 2Al + 3F_2$

D. $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$

Use the following information to answer Questions 6, 7 and 8.

The flow chart refers to a coal-fired power station. The main reaction in the furnace is

$$C(s) + O_2(g) \rightarrow CO_2(g)$$



Question 6

The reaction in the furnace produces energy.

Which of the following statements is **not** true?

A. Carbon and oxygen react together very slowly at room temperature.

B. The total enthalpy (H) of one mole of solid carbon plus one mole of gaseous oxygen is greater than the enthalpy (H) of one mole of gaseous carbon dioxide.

C. Traces of sulfur dioxide are common pollutants from a coal-fired power station.

D. Pure oxygen is used for burning the coal in order to minimise pollution.

Question 7

The purpose of the boiler is to

A. provide hot water to heat the turbine.

B. heat air that is then forced through the turbine.

C. provide steam at high pressure to drive the turbine.

D. compress air for use in driving the turbine.

Question 8

The purpose of the turbine is to convert

A. chemical energy in the coal into kinetic energy of water molecules.

B. kinetic energy of water molecules into thermal energy of the turbine.

C. kinetic energy of water molecules into kinetic energy of the turbine.

D. electrical energy in the coal into thermal energy in homes and industry.

Question 9

Some metals are deposited when a solution of their ions is electrolysed.

For a given metal, and a given amount of electric charge passed through the solution, which one or more of the following factors will affect the mass of the metal deposited?

I the current used

II the time taken for the electrolysis

III the charge on the ion

A. II only

B. III only

C. I and II only

D. I, II and III

Question 10

Which of the following is likely to oxidise $I^-(aq)$?

A. $Ag^+(aq)$

B. $Fe^{2+}(aq)$

C. $Zn^{2+}(aq)$

D. $Br^-(aq)$

Question 11

In the electrolysis of dilute aqueous NaCl, sodium ions are

A. attracted to the negative electrode where they are oxidised.

B. attracted to the negative electrode where they are reduced.

C. attracted to the negative electrode but are neither reduced nor oxidised.

D. not attracted to either electrode because water reacts preferentially.

Question 12

The discharge of excess nitrogen from our body is in the form of urea which has the chemical formula

A. $NH_2\,CO$

B. $(NH_2)_2CO$

C. $NH_2\,(CO)_2$

D. $(NH_2\,)_2\,(CO)_2$

Question 13

Which of the following represents an amino acid in a solution in which the pH is 1?

A. NH_2CH_2COOH

B. $^+NH_3CH_2COOH$

C. $NH_2CH_2COO^-$

D. $^+NH_3CH_2COO^-$

Question 14

Which of the following is **least** likely to be an amino acid obtained from the hydrolysis of a protein in food?

A. $NH_2CH_2CH_2COOH$

B. $NH_2CH(SH)COOH$

C. $NH_2CH(COOH)COOH$

D. $NH_2CH(CH_3)COOH$

Question 15

The process of respiration is described by the following equation

$$C_6H_{12}O_6\,(aq) + 6O_2\,(g) \rightarrow 6CO_2\,(g) + 6H_2O(l) \qquad \Delta H = -2803 \text{ kJ mol}^{-1}$$

How much energy is released when 2.50 L of O_2, at STP, is consumed?

A. 52.1 kJ

B. 313 kJ

C. 1168 kJ

D. 1878 kJ

Question 16

Which property shows a general decrease across the periodic table from sodium to chlorine?

A. electronegativity

B. atomic radius

C. first ionisation energy

D. oxidising strength

Question 17

Which one of the following has the largest radius?

A. Mg atom

B. Mg^{2+} ion

C. Ca atom

D. Ca^{2+} ion

Question 18

Which one of the following transitions could **not** contribute to the emission spectrum of an excited calcium atom?

A. An electron in a 5s orbital moves to a 3d orbital.

B. An electron in a 4s orbital moves to a 4p orbital.

C. An electron in a 5s orbital moves to a 4p orbital.

D. An electron in a 6p orbital moves to a 3d orbital.

Question 19

In which of the following equations does the oxide of a metal act as an acidic oxide?

A. $Na_2O(s) + H_2O(l) \rightarrow 2Na^+(aq) + 2OH^-(aq)$

B. $Na_2O(s) + 2HCl(aq) \rightarrow 2Na^+(aq) + 2Cl^-(aq) + H_2O(l)$

C. $Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$

D. $Al_2O_3(s) + 3H_2O(l) + 2OH^-(aq) \rightarrow 2Al(OH)_4^-(aq)$

Question 20

Which element is chemically most similar to the element with atomic number 15?

A. Si

B. S

C. Ar

D. As

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

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

Section B is worth approximately 74 per cent of the marks available. You should spend approximately 66 minutes on this section.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; $NaCl(s)$.

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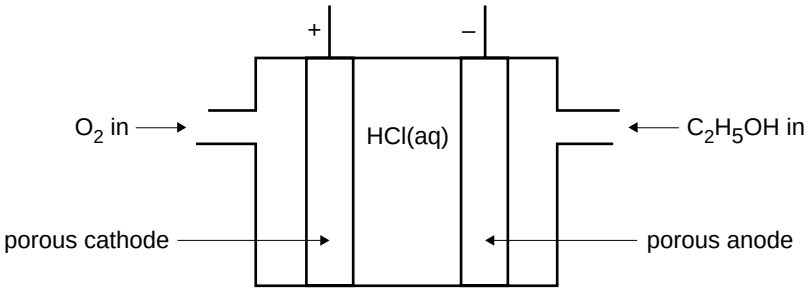
Question 1

The diagram below shows a fuel cell designed to use ethanol as a fuel.
The half cells contain HCl, an acidic electrolyte.



The cell reaction is

$C_2H_5OH(aq) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$

The anode reaction for the cell is

$C_2H_5OH(aq) + 3H_2O(l) \rightarrow 2CO_2(g) + 12H^+(aq) + 12e^-$

a. Give the cathode reaction.

_____

_____

1 mark

b. In delivering an electric current, a particular cell uses 0.46 g of ethanol in 20.0 minutes. What electric current is flowing?

4 marks

c. This cell operates at 1.10 V. How much energy, in joule, is delivered by every mole of ethanol used in the fuel cell?

2 marks

d. An alternative way of using ethanol to release energy is to mix it with petrol, then use the mixture as a fuel for cars. The energy released by a particular petrol-ethanol mixture is to be measured using an already calibrated bomb calorimeter.

Briefly describe an experimental procedure that could be used to obtain the energy released per gram of the petrol-ethanol mixture.

3 marks

Total 10 marks

Question 2

Students were investigating energy transformations in redox reactions. This involved adding a known mass of powdered zinc to 1.5 M copper (II) sulfate solution in a calorimeter and measuring the temperature change.

Two separate experiments, A and B, were conducted under the same conditions. In experiment B a greater volume of $CuSO_4(aq)$ was used than in A. The amount of copper sulfate solution used in both experiments was more than enough to react with all the zinc.

	Experiment A	**Experiment B**
Metal used	Zinc	Zinc
Amount of metal used	0.0500 mol	0.0500 mol
Volume of 1.5 M $CuSO_4(aq)$	100 mL	150 mL
Initial temperature of $CuSO_4(aq)$ solution	20.0°C	20.0°C
Temperature of solution after reaction is complete	43.4°C	35.6°C

a. **i.** Assume that 4.2 J is needed to raise the temperature of 1.0 mL of the solution by 1.0°C. Use the results of experiment A to calculate the energy released, in kJ, by the reaction between the zinc and the copper sulfate solution.

ii. Then, find the value and sign of ΔH, in kJ mol^{-1}, for the reaction

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

4 marks

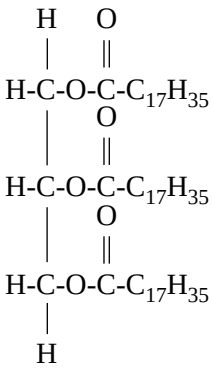
b. The temperature rise recorded for experiment B was less than in experiment A.
Give a possible explanation.

2 marks

Total 6 marks

Question 3

One of the major food groups consists of fats and oils. A molecule that is a component of fat is tristearin. Its formula is shown below.



a. **i.** Identify one functional group in the tristearin molecule by drawing a circle around it.

ii. Name this functional group. _____

2 marks

b. **i.** In the initial stage of its digestion, tristearin is broken down into smaller molecules.

Which of the following best describes the kind of chemical reaction involved in this process? Tick (✓) the box next to your selected answer.

- ☐ oxidation
- ☐ reduction
- ☐ hydrolysis
- ☐ addition
- ☐ condensation

ii. Complete the equation for the breakdown of tristearin by filling in the boxes below.

formula		**name**		**formula**		**formula**
$CH_2OCOC_{17}H_{35}$ $CH_2OCOC_{17}H_{35}$ $CH_2OCOC_{17}H_{35}$	+		→		+	
name Tristearin				**name**		**name** Stearic acid

1 + 4 = 5 marks

Total 7 marks

Question 4

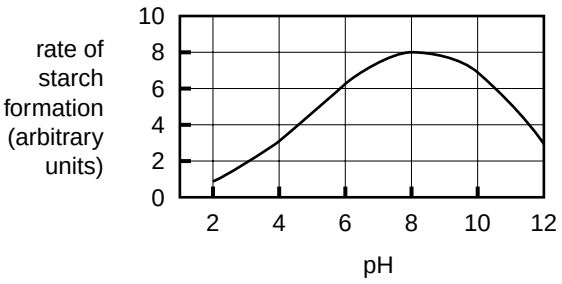
a. **Hydrogen bonding** plays a significant role in the structure of some of the carbon compounds that comprise the major food groups.

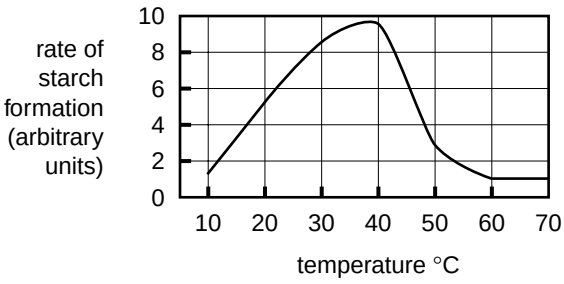
i. Explain the role that hydrogen bonding plays in the structure of proteins.

ii. How does the strength of a hydrogen bond compare with that of a single covalent bond?

2 + 1 = 3 marks

b. Enzymes are proteins that catalyse chemical reactions in biological systems. The enzyme, **starch phosphorylase**, catalyses the formation of starch from glucose in plants. Students studying the effects of pH and temperature on **starch phosphorylase** in the laboratory obtained the following results.





i. At what pH does this enzyme operate at its maximum rate?

ii. The activity of the enzyme changes with temperature.
Explain why the rate of starch formation increases as the temperature increases from 10°C to 40°C.

iii. The decreased rate of starch formation at 60ºC is due to the denaturation of the enzyme.
Explain what is meant by enzyme denaturation and how this leads to a decreased rate of reaction.

_____

_____

_____

_____

1 + 1 + 2 = 4 marks

Total 7 marks

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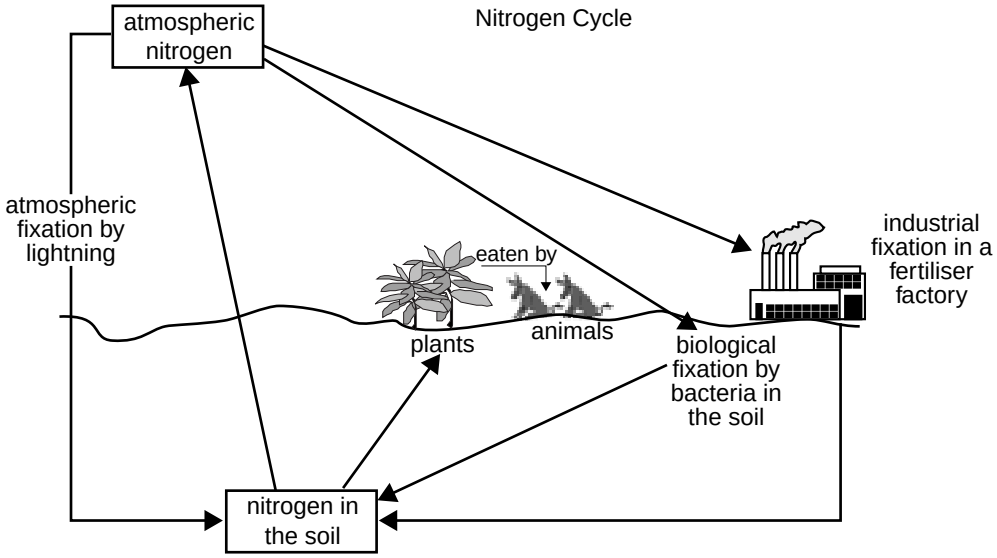
Question 5



Nitrogen is an essential element for the growth of plants and animals. The movement of nitrogen in the various pathways in the biosphere is known as the nitrogen cycle. A simple representation of this cycle is shown above.

a. Why is nitrogen fixation essential to food production?

2 marks

b. The main pathways by which conversions of nitrogen take place in the nitrogen cycle are listed below.

I $N_2 \rightarrow NH_3 \rightarrow NH_4^+$

II $N_2 \rightarrow NO \rightarrow NO_2 \rightarrow NO_3^-$

III $NO_3^- \rightarrow N_2O \rightarrow N_2$

IV $NH_3/NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$

For each of the statements in the following table, place a tick (✓) in the column under each of the pathways (I to IV) relevant to that statement. Note that each statement may refer to **more than one pathway**.

	Pathway			
	I	II	III	IV
i. pathway(s) involving nitrogen fixation				
ii. pathway(s) involving soil bacteria				
iii. pathway(s) in which nitrogen atoms undergo reduction				
iv. pathway(s) showing reaction(s) caused by lightning strikes				

4 marks

c. The production of fertilisers is a major industry in our society.
Give the formula of one nitrogenous fertiliser.

_____

1 mark

Total 7 marks

Question 6

Name two individuals who have contributed to our current understanding of atomic theory.
Describe one major contribution that each individual has made to our understanding of atomic theory.

individual 1 _____

contribution _____

_____

_____

individual 2 _____

contribution _____

_____

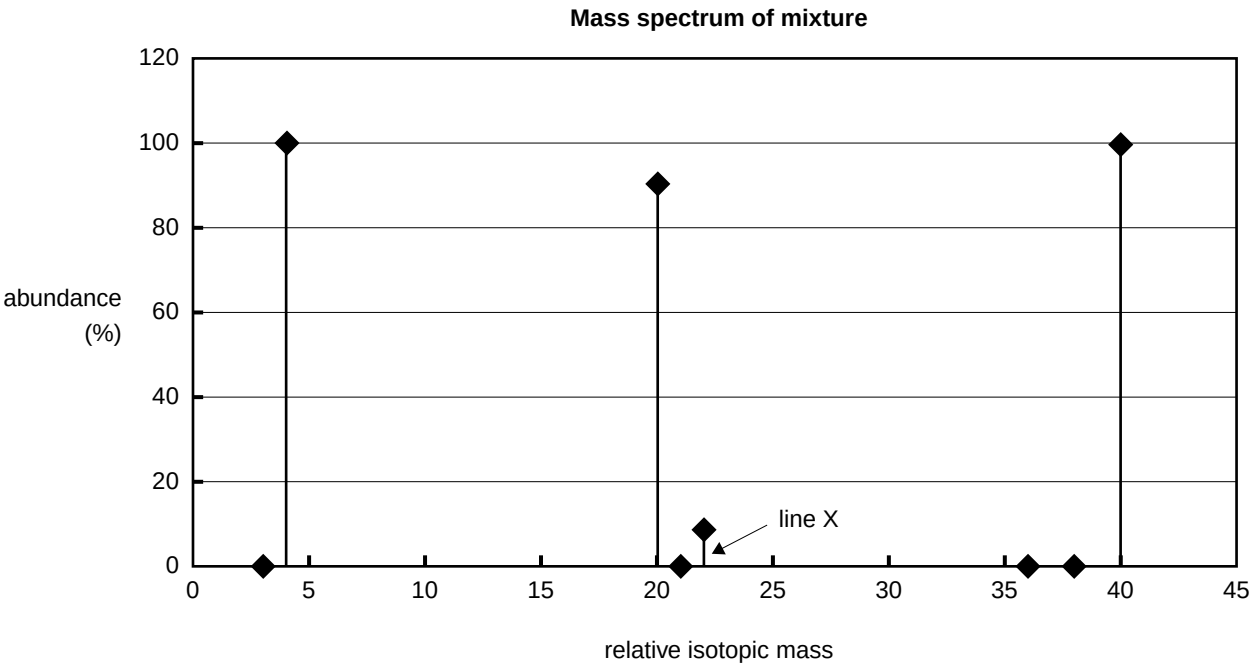
_____

4 marks

Question 7

A mass spectroscopy analysis is performed on a mixture of equal molar quantities of three noble gases. The results are given in the following table and also shown as a spectrum.

Relative isotopic mass	% abundance
3.016	0.00014
4.003	100.0
19.992	90.48
20.994	0.27
21.991	9.25
35.968	0.337
37.962	0.063
39.962	99.600



a. How many isotopes of helium are in the mixture?

1 mark

b. Give the symbol of the species that produces line X in the spectrum.

1 mark

c. Use the data in the table to calculate the relative atomic mass of argon to four significant figures.

2 marks

d. The element boron has a relative atomic mass of 10.81. Boron has two isotopes. Their relative isotopic masses are 10.0 and 11.0 respectively.

i. Calculate the percentage abundance of each of the boron isotopes.

ii. On the mass spectrum on page 16, draw in the peaks boron would produce in this mass spectrometer.

4 marks

Total 8 marks

Question 8

Iron has an atomic number of 26.

a. Give the electron configuration, using s, p, d notation, of an iron atom in its ground state.

1 mark

b. Transition metals have many similarities in their chemical properties.

Explain, in terms of current atomic theory, why iron is classified as a transition metal.

1 mark

c. The iron (III) ion exists as the complex ion, $Fe(H_2O)_6^{3+}$ ion, in water. When fluoride ions are added to a solution containing $Fe(H_2O)_6^{3+}$ ions, F^- ions replace the water ligands.

i. Write an equation for the reaction in which six water ligands are replaced by fluoride ions to form the hexafluoro complex ion.

ii. Sketch the hexafluoro complex ion, clearly showing the orientation of the ligands around the central cation.

iii. What kind of bonding exists between the ligands and the central ion in $Fe(H_2O)_6^{3+}$?

3 marks

d. Explain, in terms of ionisation energy, why Group I elements typically exhibit a +1 (but not +2 or +3) oxidation state in their compounds.

2 marks

Total 7 marks

END OF QUESTION AND ANSWER BOOK

CHEMISTRY

Written examination 2

DATA SHEET

Directions to students

Detach this data sheet during reading time.

This data sheet is provided for your reference.

Physical constants

$F = 96\,500\ \text{C mol}^{-1}$

$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$

1 atm = 101 325 Pa = 760 mmHg

0 °C = 273 K

STP = 22.4 mol^{-1}

Ideal gas equation

$pV = nRT$

The electrochemical series

	$E°$ in volt
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(1)$	+1.23
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	–0.28
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	–1.03
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.67
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.34
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$K^+(aq) + e^- \rightarrow K(s)$	–2.93
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.02

Periodic table of the elements

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.6	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98.1	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 197.0	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)															

Lanthanides

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.3	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

Actinides

90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (255)	103 Lr (256)