VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2004

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter:
Words									

CHEMISTRY

Written examination 2

Friday 12 November 2004

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*	*Suggested times (minutes)*
A	20	20	20	27
B	9	9	54	63
			Total 74	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 17 pages, with a detachable data sheet in the centrefold.
- Answer sheet for multiple-choice questions.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- 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.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

SECTION A – Multiple-choice questions

Instructions for Section A

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

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Section A is worth approximately 27 per cent of the marks available.

Question 1

The number of neutrons in an atom of ^{131}I is

A. 53

B. 78

C. 131

D. 184

Question 2

Nuclear energy is often proposed as an alternative to fossil-fuel energy sources. Power stations based on nuclear fission are widely used in some parts of Europe, however there are no nuclear fusion reactors in use.

Nuclear fusion is not currently used in preference to nuclear fission because

A. it is a source of greenhouse gas emissions.

B. it uses very rare metals as an energy source.

C. it is difficult to dispose of its waste products.

D. its technology is still not sufficiently developed.

Question 3

In the electrolytic production of aluminium metal from alumina (Al_2O_3), the alumina is dissolved in cryolite (Na_3A1F_6). The anodes and cathodes are made of carbon. The electrode reactions may be represented by

$$C + 2O^{2-} \rightarrow CO_2 + 4e^-$$

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

The net reaction for this electrolysis process is

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

B. $Al^{3+} + C + 2O^{2-} \rightarrow Al + CO_2$

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

D. $4Al^{3+} + 6O^{2-} + O_2 + C \rightarrow 2Al_2O_3 + CO_2$

Questions 4, 5 and 6 refer to the following information.

The oxidation of methane (natural gas) can be used to produce electricity in a gas-fired power station. Methane can also be oxidised to produce electricity in a fuel cell. The overall equation for the oxidation of methane is

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta H = -900 \text{ kJ mol}^{-1}$$

Question 4

In a gas-fired power station, the energy available from the above reaction is used to convert water in a boiler from liquid water to steam,

$$H_2O(l) \rightarrow H_2O(g) \qquad \Delta H = +44.0 \text{ kJ mol}^{-1}$$

The maximum mass of water, in grams, that could be converted from liquid water to steam by the complete oxidation of one mole of methane is

A. 20.5

B. 61.8

C. 184

D. 368

Question 5

In a fuel cell based on the oxidation of methane, the equation for the anode half reaction is

$$CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$$

The corresponding equation for the half reaction at the cathode is

A. $2H_2O(l) + 4e^- \rightarrow 4H^+(aq) + O_2(g)$

B. $4H^+(aq) + O_2(g) \rightarrow 2H_2O(l)$

C. $2H_2O(l) \rightarrow 4H^+(aq) + O_2(g) + 4e^-$

D. $4H^+(aq) + O_2(g) + 4e^- \rightarrow 2H_2O(l)$

Question 6

A fuel cell is set up based on the oxidation of methane. Again, the equation for the anode half reaction is

$$CH_4(g) + 2H_2O(l) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$$

Assuming that all the energy of the oxidation reaction is converted to electricity, the amount of electric charge, in coulomb, obtained from the oxidation of one mole of methane is closest to

A. 8×10^2

B. 1×10^3

C. 8×10^5

D. 1×10^6

Question 7

A student is planning to set up a demonstration of a galvanic cell using half cells constructed as follows.

- Half cell 1: a calcium electrode in a beaker containing an aqueous solution of Ca^{2+} ions
- Half cell 2: a platinum electrode in a beaker containing an aqueous solution of a mixture of Sn^{4+} and Sn^{2+} ions

A salt bridge would connect the two beakers. The electrodes would be attached to a voltmeter.

This particular cell is impractical because

A. solid calcium (Ca) will react directly to reduce water to hydrogen gas.

B. there is no solid tin (Sn) in the half cell containing $Sn^{4+}(aq)$ and $Sn^{2+}(aq)$.

C. there are no known ionic compounds of calcium that are soluble in water.

D. $Sn^{4+}(aq)$ will be in contact with Ca and will oxidise it to $Ca^{2+}(aq)$.

Question 8

In which one of the following sets of substances are **all** members of the set able to undergo a spontaneous redox reaction with pure water?

A. Fe, Co^{2+}, Cl_2

B. F_2, Mg, Au^+

C. H^+, Na^+, Br_2

D. Li, F_2, Ag^+

Question 9

96.5 C of electricity is used to completely deposit silver metal (Ag) from an aqueous solution in which the silver ion is present as $Ag^+(aq)$. Another 96.5 C is used to completely deposit copper (Cu) from an aqueous solution in which the copper ion is present as $Cu^{2+}(aq)$.

The silver metal deposited would

A. have half the mass of the copper deposited.

B. have twice the mass of the copper deposited.

C. be half the mole of the copper deposited.

D. be twice the mole of the copper deposited.

Question 10

The energy (kJ mol^{-1}) required to remove the first five electrons from an atom of element X is shown in the table.

Electron number	1	2	3	4	5
Energy	495	4560	6910	9550	13420

Element X is most likely to be located in the periodic table in group

A. I

B. II

C. III

D. IV

Question 11

The isotope ^{35}S is radioactive and decays by emitting a beta particle (an electron) to form an isotope of a different element.

During the decay process which of the following occurs?

	Mass number	Atomic number	Nuclear charge
A.	decreases	decreases	decreases
B.	remains unchanged	decreases	increases
C.	increases	increases	remains unchanged
D.	remains unchanged	increases	increases

Question 12

The elements in Group IV of the periodic table become more metallic in character down the group.

This trend is best explained by the

A. core charge decreasing.

B. atomic size increasing.

C. ionisation energy increasing.

D. number of outer shell electrons decreasing.

Question 13

The electron configurations of four elements are listed.

The electron configuration of the element least likely to act as a reductant is

A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^1$

B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

D. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

Question 14

Which of the following compounds of manganese can be reduced to form the other three?

A. MnO

B. MnO_2

C. $KMnO_4$

D. K_2MnO_4

Question 15

The formula of an amphoteric oxide formed by a third period element is

A. Na_2O

B. Al_2O_3

C. P_4O_{10}

D. Cl_2O_7

Question 16

Naturally occurring copper exists as two isotopes, ^{63}Cu and ^{65}Cu. The relative atomic mass of copper is 63.6. The ratio of ^{63}Cu to ^{65}Cu in natural copper is approximately

A. 63 : 65

B. 1 : 1

C. 1 : 3

D. 3 : 1

Question 17

An enzyme is heated from 25°C to 100°C.

The part that is **least** affected by the increase in temperature is the

A. primary structure.

B. secondary structure.

C. tertiary structure.

D. active site.

Question 18

Maltose is a disaccharide formed by a condensation reaction between glucose ($C_6H_{12}O_6$) molecules.

The molar mass of maltose, in g mol^{-1}, is

A. 180

B. 324

C. 342

D. 360

Question 19

Which of the following can be stored in the human body for use as an energy reserve?

I glucose

II fat

III glycogen

A. I only

B. I and II only

C. II and III only

D. I and III only

Question 20

The main source of the sun's energy is

A. fusion of hydrogen to form helium.

B. fusion of helium to form carbon.

C. fusion of carbon to form heavier atoms.

D. All of the above.

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

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

Section B is worth approximately 73 per cent of the marks available.

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)

Question 1

Give the chemical **formula** for

i. A nitrogen-containing compound that is the end waste product of the digestion of proteins

____

1 mark

ii. The carboxyl functional group

____

1 mark

iii. An oxide from period 3 that reacts with NaOH but **not** with HCl

____

1 mark

iv. A compound that is always a reactant in a hydrolysis reaction

____

1 mark

v. The element whose ion of charge +3 has an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

____

1 mark

Total 5 marks

Question 2

Some atoms of element X in a discharge tube are found to have the electron configuration $1s^2 2s^2 2p^4 4s^1$.

a. Give the name, or the chemical symbol, of element X.

1 mark

b. If the electron configuration changed from $1s^2 2s^2 2p^4 4s^1$ to $1s^2 2s^2 2p^4 3s^1$, would the process be exothermic or endothermic? Explain your reasoning.

2 marks

c. Write the ground state electron configuration for atoms of element X.

1 mark

Total 4 marks

Question 3

a. A bomb calorimeter may be calibrated using a substance with a well-known heat of combustion. A commonly used calibrating agent is benzoic acid ($C_7H_6O_2$) which has a heat of combustion of 3227 kJ for each mole of benzoic acid.

i. 2.50 g of pure solid benzoic acid is placed in a calorimeter and completely reacted with oxygen. The temperature rise of the calorimeter is observed to be 8.90°C.

Calculate the calibration factor of the calorimeter in kJ°C^{-1}.

3 marks

ii. Give a chemical equation for the reaction of benzoic acid with oxygen. Include the **correct sign and magnitude** of the ΔH for the reaction.

3 marks

b. A second bomb calorimeter is used for the following two experiments. The calibration factor for this calorimeter is 5.56 $kJ°C^{-1}$.

A lump of lignite (brown coal) is freshly taken from the ground and crushed into a powder.

Two samples of this powdered lignite are weighed. Each sample has a mass of 3.20 g.

i. Sample 1 is placed in the calorimeter and completely reacted with oxygen.

The temperature rise of the calorimeter is found to be 2.21°C.

Calculate the heat of combustion of the fresh lignite in kJ g^{-1}.

2 marks

ii. Sample 2 is placed in an oven for 2 hours where it is kept at a temperature of 100°C.

It is cooled and weighed. Its mass decreases to 2.15 g after heating.

It is then completely reacted with oxygen in the calorimeter.

The temperature rise of the calorimeter is found to be 2.66°C.

Explain why the combustion of the second sample of lignite appears to release significantly more energy than the first sample.

1 mark

Total 9 marks

Question 4

A small electric vehicle is powered by rechargeable lead-acid car batteries. The energy that drives the vehicle comes from the cell reaction

$$Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$$

The equation for the anode half reaction is

$$Pb(s) + H_2SO_4(aq) \rightarrow PbSO_4(s) + 2H^+(aq) + 2e^-$$

a. Write the equation for the cathode half reaction.

1 mark

b. In this vehicle, each battery operates at 12.0 V. When fully charged, the vehicle can travel on a level surface for 2.5 hours with an average energy consumption of 1.0 kJ s^{-1}, after which time the batteries must be recharged.

i. How much energy, in kJ, is used by the vehicle in travelling for 2.5 hours?

1 mark

ii. Write the equation for the overall chemical reaction that occurs when the battery is being recharged.

1 mark

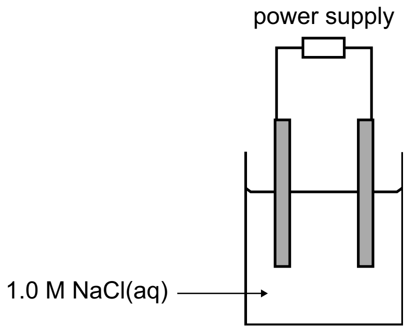
iii. What voltage should be used to recharge each battery?

1 mark

Total 4 marks

Question 5

A student carries out the electrolysis of a 1.0 M solution of sodium chloride using graphite electrodes. The set-up for this experiment is shown below.



a. Write an equation for the half reaction that occurs at the cathode.

1 mark

b. Two different gases are produced at the anode. Write equations for the two half reactions that result in the formation of these two gases.

i. Equation for half reaction that produces gas 1

1 mark

ii. Equation for half reaction that produces gas 2

1 mark

c. Using the same current and electrodes, the student carries out a second electrolysis, this time of a saturated solution (approximately 6 M) of sodium chloride instead of a 1.0 M solution. What difference, if any, would you expect in the product or products formed at the

i. cathode?

1 mark

ii. anode?

1 mark

Total 5 marks

Question 6

a. By referring to their electron configurations, explain why metals in the first transition series of the periodic table typically have several different oxidation states while Group II metals have only one.

2 marks

b. Predict the trend in the following properties of the second period elements, moving from lithium to fluorine, giving an explanation in support of each prediction.

Property	**Increases or decreases?**	**Explanation for predicted trend**
Atomic size		
Electronegativity		

4 marks

c. There is also a general trend in first ionisation energy both across periods and down groups of the periodic table.

i. What is meant by the term ionisation energy?

1 mark

ii. Given that the atomic size of potassium is greater than that of sodium, explain why the first ionisation energy of sodium is greater than that of potassium.

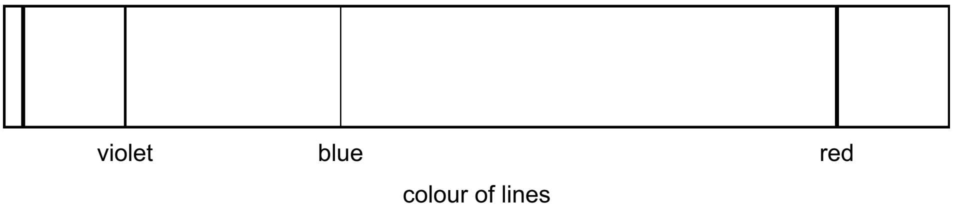
1 mark

Total 8 marks

CONTINUED OVER PAGE

Question 7

When a high-voltage electric current is passed through hydrogen gas, light is produced. If the light is passed through a spectrometer an emission spectrum is observed. The visible part of the spectrum is shown in the diagram.



a. Explain how the study of the emission spectrum of hydrogen, with its single electron, has been used to develop an understanding of its electron structure.

2 marks

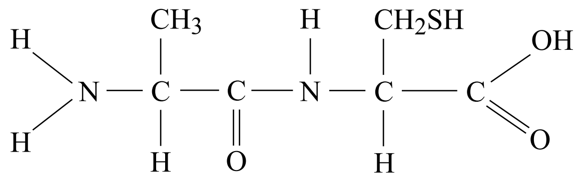
b. Hydrogen has three isotopes: ^{1}H, ^{2}H, ^{3}H. Would you expect the three isotopes to produce essentially the same atomic emission spectrum? Give a reason for your answer.

2 marks

Total 4 marks

Question 8

Consider the dipeptide with the following structural formula



a. On the above formula, circle the peptide link.

1 mark

b. When this dipeptide is hydrolysed, two amino acids are formed.

- Draw a **structural formula** for one of these amino acids as it would exist in a solution of pH 2.

- Draw a **structural formula** for the **other** amino acid as it would exist in a solution of pH 12.

3 marks

c. Nitrogen gas in the atmosphere cannot be used directly by plants to make amino acids. Give the formula of a nitrogen-containing molecule or ion which can be taken up by plants. Describe one process by which nitrogen in the atmosphere is converted into that molecule or ion.

____

____

____

2 marks

Total 6 marks

Question 9

a. The label on a packet of dry biscuits gives the following nutritional information.

serving size	35 g
protein	3.7 g
fat – saturated	0.80 g
– unsaturated	0.10 g
carbohydrates – sugars and starches	26.0 g
– cellulose fibre	3.5 g

i. Given that the energy available to the body per gram of

– protein is 16 kJ

– fat is 37 kJ

– digestible carbohydrate is 17 kJ

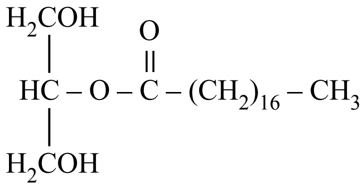
calculate the total possible energy available to the body per gram of biscuit.

2 marks

ii. A sample of the biscuit is burned in a bomb calorimeter to determine its energy value. The result indicated that 1 gram of biscuit releases 17 kJ. Give a possible explanation for the difference between this value and that calculated in part i.

1 mark

b. Glycerol monostearate is used as an emulsifying agent in some ice creams. It can be formed from the reaction between glycerol and stearic acid. It has the semi-structural formula



i. What features must be present in a molecule such as glycerol monostearate for it to be able to act as an emulsifying agent?

2 marks

ii. Glycerol and stearic acid can also react to form a triglyceride.

Write an equation for the reaction between glycerol and stearic acid to form a triglyceride.

2 marks

iii. Is stearic acid a saturated or unsaturated carboxylic acid? Give a reason for your answer.

2 marks

Total 9 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 C mol^{-1}
R = 8.31 J K^{-1} mol^{-1}
1 atm = 101 325 Pa = 760 mmHg
0°C = 273 K
Molar volume at STP = 22.4 L mol^{-1}
Avogadro constant = 6.02 × 10^{23} 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)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Uun	111 Uuu	112 Uub		114 Uuq		116 Uuh		118 Uuo

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

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 (259)	103 Lr (260)

END OF DATA SHEET