VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education
2005

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Letter

Figures									
Words									

CHEMISTRY
Written examination 2

Friday 11 November 2005

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	60	63
			Total 80	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 19 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 unauthorised electronic 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.

Question 1

The trisaccharide formed from the reaction of three glucose ($C_6H_{12}O_6$) molecules has the formula

A. $C_{18}H_{36}O_{18}$

B. $C_{18}H_{34}O_{17}$

C. $C_{18}H_{32}O_{16}$

D. $C_{18}H_{30}O_{15}$

Question 2

The reaction between a glycerol molecule and three long-chain carboxylic acid molecules is a

A. condensation reaction and the product contains a $-\underset{\underset{O}{\|}}{C}-O-C-$ group.

B. hydrolysis reaction and the product contains a $-\underset{\underset{O}{\|}}{C}-O-C-$ group.

C. condensation reaction and the product contains a $-C-O-O-C-$ group.

D. hydrolysis reaction and the product contains a $-C-O-O-C-$ group.

Question 3

The substances below are present in the food we eat.
Which one provides the lowest amount of energy per gram for the human body?

A. tristearin (a triglyceride)

B. glycine (an amino acid)

C. cellulose (a polysaccharide)

D. glucose (a monosaccharide)

SECTION A – continued

Question 4

Nitrifying and denitrifying bacteria play important roles in the nitrogen cycle. They are involved in the following reactions.

$$NH_4^+(aq) \xrightarrow{\textit{nitrifying bacteria}} NO_3^-(aq) \qquad \text{reaction 1}$$

$$NO_3^-(aq) \xrightarrow{\textit{denitrifying bacteria}} N_2(g) \qquad \text{reaction 2}$$

Which one of the following alternatives correctly describes both of these reactions?

	Reaction 1	Reaction 2
A.	nitrogen fixation	oxidation
B.	oxidation	nitrogen fixation
C.	nitrogen fixation	reduction
D.	oxidation	reduction

Question 5

The reaction between solutions of hydrochloric acid and sodium hydroxide can be represented by the following equation.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \qquad \Delta H = -56 \text{ kJ mol}^{-1}$$

60.0 mL of 2.0 M HCl, at 21°C, is mixed with 40.0 mL of 2.0 M NaOH, also at 21°C, in a well-insulated calorimeter. The calibration factor for the calorimeter and contents is 420 J K^{-1}.

The final temperature, in °C, of the resultant solution in the calorimeter would be closest to

A. 11

B. 32

C. 37

D. 52

Question 6

Which one of the following would be predicted to spontaneously oxidise aqueous iodide ions but not aqueous chloride ions?

A. $Au^+(aq)$

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

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

D. $Br_2(aq)$

Question 7

The rechargeable nickel-cadmium cell is used to power small appliances such as portable computers. When the cell is being used, the electrode reactions are represented by the following equations.

$$NiO_2(s) + 2H_2O(l) + 2e^- \rightarrow Ni(OH)_2(s) + 2OH^-(aq)$$
$$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$$

Which of the following occurs during the **recharging** of the nickel-cadmium cell?

I cadmium is deposited on the negative electrode

II the pH of the electrolyte increases

III the direction of electron flow in the external circuit is from the anode to the cathode

A. I only

B. I and II only

C. II and III only

D. I and III only

Question 8

A galvanic cell consists of one half cell that is made up of an inert graphite electrode in a solution containing 1.0 M $Fe^{2+}(aq)$ and 1.0 M $Fe^{3+}(aq)$ at 25°C.

Which one of the following could be used as the second half cell so that the polarity of the electrode in this second half cell is positive?

A. a lead electrode in a solution of 1.0 M $Pb^{2+}(aq)$

B. a silver electrode in a solution of 1.0 M $Ag^+(aq)$

C. an iron electrode in a solution of 1.0 M $Fe^{2+}(aq)$

D. an inert graphite electrode in a solution of 1.0 M $Br^-(aq)$

Questions 9 to 11 refer to the following information.

A copper disc is to be silver-plated in an electrolytic cell. The disc forms one electrode and a silver rod the other electrode. The electrolyte provides a source of $Ag^+(aq)$.

Question 9

The disc to be plated is connected to the

A. positive terminal of a battery so that oxidation occurs at the disc.

B. positive terminal of a battery so that reduction occurs at the disc.

C. negative terminal of a battery so that oxidation occurs at the disc.

D. negative terminal of a battery so that reduction occurs at the disc.

Question 10

The mass of silver to be deposited is 0.150 g.

If the current is held steady at 1.50 amps, the time, in seconds, that it takes to complete the plating is closest to

A. 90

B. 180

C. 200

D. 360

Question 11

An identical disc is to be gold-plated with a solution containing $Au^{3+}(aq)$ as the electrolyte using a current of 1.50 amps.

The ratio of the time that is needed to plate the disc with 0.150 g of gold to the time needed to plate the disc with 0.150 g of silver is closest to

A. 1 to 3

B. 1 to 1.6

C. 1.6 to 1

D. 3 to 1

Question 12

An electrolytic cell is used commercially to extract aluminium from its ore. The anode and cathode of this electrolytic cell are composed of

	anode	cathode
A.	carbon	carbon
B.	carbon	iron
C.	iron	carbon
D.	iron	iron

Question 13

In which one of the following processes will the ΔH have the opposite sign to that of the other three?

A. $I_2(s) \rightarrow I_2(g)$

B. $Na^+(g) + e^-(g) \rightarrow Na(g)$

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

D. $2NaCl(l) \rightarrow 2Na(l) + Cl_2(g)$

Question 14

Element X has an atomic radius that is smaller than that of sulfur. In chemical reactions, element X commonly forms an ion that has the same electron configuration as the Sc^{3+} ion.

Element X could be

A. oxygen.

B. chlorine.

C. argon.

D. potassium.

Question 15

In which one of the following sets of chromium-containing compounds do the chromium atoms all have the same oxidation number?

A.	Cr_2O_3	$K_2Cr_2O_7$	Na_2CrO_4
B.	$CrCl_2$	Cr_2O_3	$K_2Cr_2O_7$
C.	Cr_2O_3	$CrCl_3$	$Cr(NO_3)_3$
D.	Na_2CrO_4	CrO_3	$Cr(NO_3)_3$

Question 16

Sodium and chlorine are both in Period 3.

You would expect sodium to have

A. the lower ionisation energy and the lower electronegativity.

B. the higher ionisation energy and the lower electronegativity.

C. the lower ionisation energy and the higher electronegativity.

D. the higher ionisation energy and the higher electronegativity.

Question 17

The noble gases (helium to radon) have an outer shell electron configuration of

A. s^2

B. s^2p^6

C. either s^2 or s^2p^6

D. either s^2p^6 or $s^2p^6d^{10}$

Question 18

Potassium has a radioactive isotope, ^{40}K. One of the ways this isotope disintegrates leads to the emission of a beta particle (an electron) by the ^{40}K nucleus.

The new nucleus produced by this disintegration is

A. $^{40}K^+$

B. ^{41}K

C. ^{40}Ar

D. ^{40}Ca

Question 19

Consider the following three compounds which contain complex ions that involve iron

I $[Fe(NH_3)_6]Cl_3$

II $K_3[FeCl_6]$

III $K_4[FeCl_6]$

The oxidation state of the iron in each of these compounds is

	I	II	III
A.	+3	–3	–2
B.	+3	+3	+2
C.	+6	+6	+6
D.	+3	–3	–4

Question 20

Which one of the following is **least likely** to act as a ligand with Fe^{3+} ions?

A. F^-

B. CN^-

C. H_2O

D. NH_4^+

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

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

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

From the following list of elements

Li	Be	B	C	N	O	F
Na	Mg	Al	Si	P	S	Cl

give the symbol or name for

a. the most electronegative element ____________________

b. the element that commonly forms an ion which has an electron configuration of $1s^2 2s^2 2p^6$ and a –2 charge ____________________

c. an element that forms an amphoteric oxide ____________________

d. an element X that forms oxides with the formula XO and XO_2 ____________________

e. an element that is found in proteins but **not** in carbohydrates____________________

Total 5 marks

Question 2

Magnesium has three naturally occurring isotopes. Their relative abundances and masses are given in the table below.

	Percentage abundance	**Relative isotopic mass**
^{24}Mg	78.99	23.985
^{25}Mg	10.00	24.986
^{26}Mg	11.01	25.983

a. The abundances and relative isotopic masses have been determined experimentally. What instrument is commonly used to obtain this information?

1 mark

b. Using the information above, show how the relative atomic mass of magnesium can be determined. Calculate your answer to an appropriate number of significant figures.

3 marks

c. Calcium is in the same group of the periodic table as magnesium.

i. Explain why Mendeleev would have placed these two elements in the same vertical group.

ii. The electronegativity of magnesium (1.31) is greater than that of calcium (1.00). Give a brief explanation for this difference.

iii. Write the electron configuration, in terms of shells and subshells, for the calcium atom.

iv. Write the electron configuration, in terms of shells and subshells, for the Ca^{2+} ion.

v. The radius of the calcium atom is 1.97×10^{-10} m.
The radius of the Ca^{2+} ion is 9.9×10^{-11} m.
Explain why the calcium atom is significantly larger than the Ca^{2+} ion.

1 + 2 + 1 + 1 + 1 = 6 marks

Total 10 marks

Question 3

a. Coke, which is essentially pure carbon, is widely used as a fuel. Its complete combustion can be represented by the following equation.

$$C(s) + O_2(g) \rightarrow CO_2(g) \qquad \Delta H = -393 \text{ kJ mol}^{-1}$$

However, under certain conditions, the combustion is incomplete and the following reaction also occurs.

$$2C(s) + O_2(g) \rightarrow 2CO(g) \qquad \Delta H = -232 \text{ kJ mol}^{-1}$$

Calculate the energy, in kJ, released when 2.00 tonne (1 tonne = 10^6 gram) of coke is reacted with oxygen if 80% of the coke is oxidised to carbon dioxide and the remaining 20% is oxidised to carbon monoxide.

4 marks

b. Carbon is also a reactant in nuclear fusion reactions in some stars. One such reaction can be represented by the following equation.

$$^{12}_{6}C + ^{4}_{2}He \rightarrow ^{16}_{8}O + \text{energy}$$

For a given amount of carbon, significantly more energy is released in nuclear fusion reactions than in chemical reactions.

i. What is the source of the energy released in this nuclear fusion reaction?

ii. Why is nuclear fusion **not** currently used as an energy source in our society?

1 + 1 = 2 marks

c. Consider the following list of forms of energy.

chemical electrical mechanical nuclear solar thermal

In a coal-fired power station, the energy released from the combustion of coal undergoes several energy conversions before electricity is generated.

i. Using the forms of energy listed above, complete the energy conversions that occur in the following stages of a coal-fired power station. (The same form of energy may be used more than once.)

Coal is oxidised to generate steam ________________ energy to ________________ energy

Steam is used to drive a turbine ________________ energy to ________________ energy

The turbine drives a generator ________________ energy to ________________ energy

ii. The amount of electrical energy obtained in a coal-fired power station is generally less than half of the available energy in the coal. What happens to the rest of the energy released when the coal is burnt?

____

____

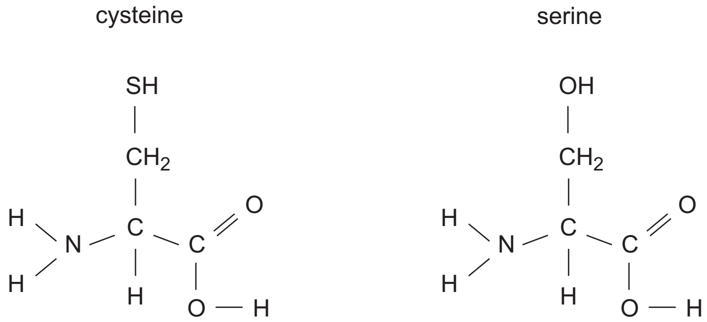
3 + 1 = 4 marks

Total 10 marks

CONTINUED OVER PAGE

Question 4

a. Two common α amino acids (2-amino acids) are cysteine and serine. Their structural formulas are given below.



i. What chemical feature must an amino acid have in order to be classified as an **α** amino acid?

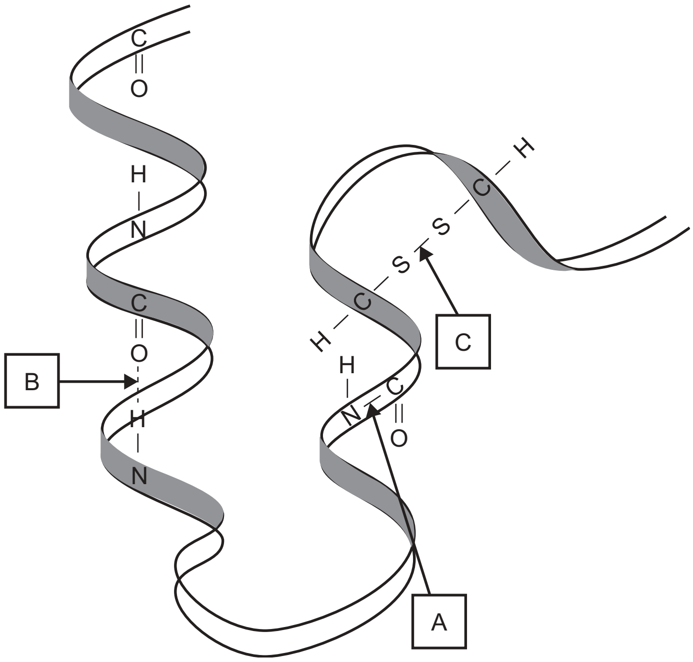
___

___

ii. Cysteine and serine can combine together to form **two** different dipeptides. Draw the structural formulas of these two dipeptides.

1 + 2 = 3 marks

b. Enzymes, which are composed mostly of protein, catalyse many chemical reactions. The structure of a portion of an enzyme, with some of its constituent atoms shown, is represented below.



i. Name the type of chemical bond present in the parts labelled.

A ____________________

B ____________________

C ____________________

ii. Why is the tertiary structure of an enzyme essential to its function?

____

____

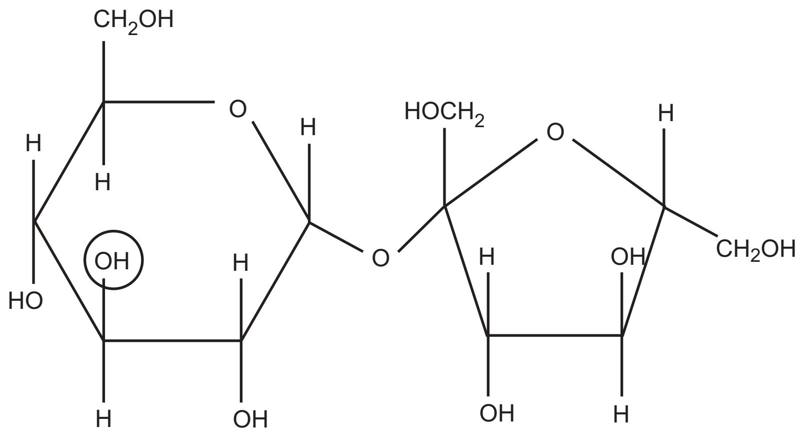
____

3 + 1 = 4 marks

Total 7 marks

Question 5

Sucrose is a disaccharide. Bees use an invertase enzyme to convert sucrose to an equimolar mixture of glucose and fructose. The structural formula of sucrose is given below and one of the functional groups in the molecule has been circled.



a. **i.** Give the name of the functional group circled in the structural formula of sucrose.

____

ii. To which of the major food groups does sucrose belong? ____________________

iii. Given that glucose has a six-membered ring structure, draw the structural formula of glucose.

3 marks

b. What simple molecule is the other reactant in the conversion of sucrose to glucose and fructose?

____

1 mark

c. The invertase enzyme can be isolated and used in the laboratory to form glucose and fructose from sucrose. In a particular set of experiments, equivalent amounts of the enzyme were mixed with three sucrose solutions of equal concentrations. One of the solutions was kept at 5°C throughout the experiment, one at 35°C and the last at 95°C.

The following gives the percentage yield of glucose after 30 minutes.

Temperature at which the experiment was carried out	**Percentage yield of glucose**
5°C	10
35°C	95
95°C	2

Explain why the percentage yield is higher at 35°C than at

i. 5°C

____

____

____

ii. 95°C

____

____

____

2 marks

Total 6 marks

Question 6

Give concise explanations for each of the following.

a. Food chemists quote the energy content of food in kJ g^{-1}, rather than kJ mol^{-1}.

1 mark

b. Hydrogen gas is bubbled through a solution of 1.0 M Fe^{3+}(aq) ions. On the basis of the electrochemical series, a redox reaction is predicted to occur. In practice, no reaction occurs at room temperature.

1 mark

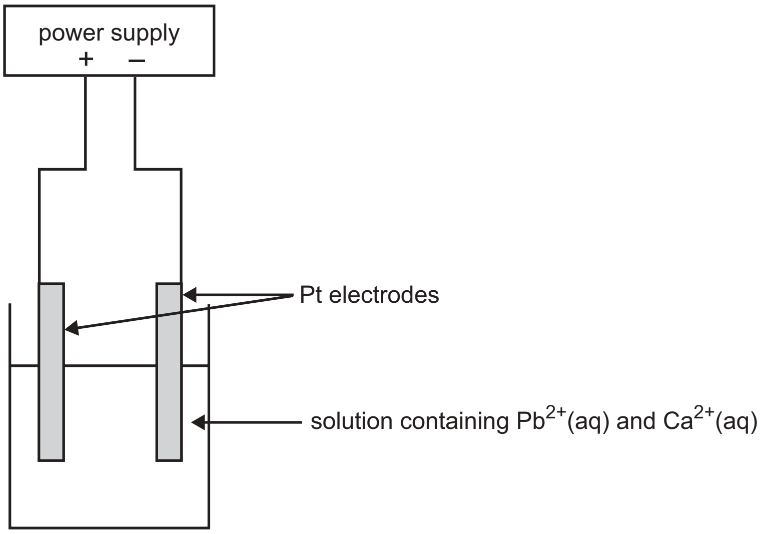
c. The oxidation state of iron, in its compounds, is normally either +2 or +3, whereas that of calcium, in its compounds, is +2 only.

2 marks

Total 4 marks

Question 7

A mineral ore contains a mixture of compounds of lead and calcium, in approximately equal proportions. A chemist extracts the metal ions by roasting the ore in air and treating the product with acid. The solution that contains the $Pb^{2+}(aq)$ and $Ca^{2+}(aq)$ is then placed in an electrolytic cell as shown in the diagram below.



a. Label the anode and cathode of the cell.

1 mark

b. When the current begins to flow in the cell, write equations for the half reaction that is likely to occur at the

- positive electrode

___

- negative electrode

___

2 marks

c. After some time has elapsed, a new half reaction occurs at one of the electrodes. Write the equation for this half reaction.

___

___

1 mark

d. If the chemist had used copper electrodes instead of platinum electrodes, how would this have affected the half reaction at the anode?

___

___

1 mark

Total 5 marks

Question 8

One type of 'breathalyser' instrument used by police for the measurement of the concentration of alcohol in a driver's breath is a fuel cell. An acidic electrolyte is used. Ethanol is oxidised to ethanoic acid at one electrode and oxygen from the air is converted to water at the other.

The overall equation for this reaction is

$$C_2H_5OH(aq) + O_2(g) \rightarrow CH_3COOH(aq) + H_2O(l)$$

a. Write the equation for the half reaction at the anode.

2 marks

b. A motorist who has consumed alcohol blows into the fuel cell. If the breath entering the cell provides alcohol at the rate of 3.0×10^{-5} g per second, calculate the maximum current, in amps, that the cell would produce.

3 marks

c. The nature of the electrodes in the cell is essential to the effective operation of the breathalyser. State **two** important functions that the electrodes must perform.

Function 1 ____________________

Function 2 ____________________

2 marks

Total 7 marks

Question 9

Give balanced equations for the following reactions.

a. The complete oxidation of glucose ($C_6H_{12}O_6$) in plant and animal cells.

2 marks

b. The formation of helium by nuclear reaction in the sun.

1 mark

c. The reaction between ammonia and sulfuric acid to form ammonium sulfate fertiliser.

1 mark

d. The reaction of an oxide of sulfur with aqueous sodium hydroxide.

2 marks

Total 6 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