SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

										Letter
Figures										
Words										

Victorian Certificate of Education 2000

CHEMISTRY

Written examination 2

Wednesday 8 November 2000: 9.00 am to 10.45 am
Reading time: 9.00 am to 9.15 am
Writing time: 9.15 am to 10.45 am
Total writing time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*
A	20	20
B	7	7

Directions to students

Materials
Question and answer book of 16 pages, with a detachable Data sheet in the centrefold.
Answer sheet for multiple-choice questions. You should have at least one pencil and an eraser.
An approved calulator may be used.

The task
Detach the Data sheet from the centre of this book during reading time.
Please ensure that you write your **student number** in the space provided on this book and 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.
This paper consists of two sections, Section A and Section B.
Answer **all** questions from Section A. Section A is worth 20 marks.
Section A questions should be answered on the answer sheet provided for multiple-choice questions.
Answer **all** questions from Section B. Section B is worth 51 marks.
Section B questions should be answered in the spaces provided in this book.
There is a total of 71 marks available.
Working space is provided throughout this book.
All written responses should be in English.

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

SECTION A – Multiple-choice questions

Specific instructions for Section A

Section A consists of 20 multiple-choice questions. Section A is worth approximately 28 per cent of the marks available. You should spend approximately 25 minutes on this section.

Choose the response that is **correct** or **best answers** the question. Indicate your choice on the multiple-choice answer sheet according to the instructions on that sheet.

A correct answer is worth 1 mark, an incorrect answer is worth no marks. No mark will be given if more than one answer is completed for any question. Marks will **not** be deducted for incorrect answers. You should attempt every question.

Question 1

The ground state electronic configuration for $_{28}Ni^{2+}$ is

A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4p^6$

B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8$

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

Question 2

300 mL of 1.5 M HCl is mixed with 300 mL of 1.0 M NaOH in a thermally insulated container. They react according to the equation

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

The initial temperature of each solution before mixing was 18 °C. If 2.5 kJ is required to raise the temperature of 600 mL of water by 1.0 °C, then the final temperature, in °C, of the solution after mixing would be about

A. 10

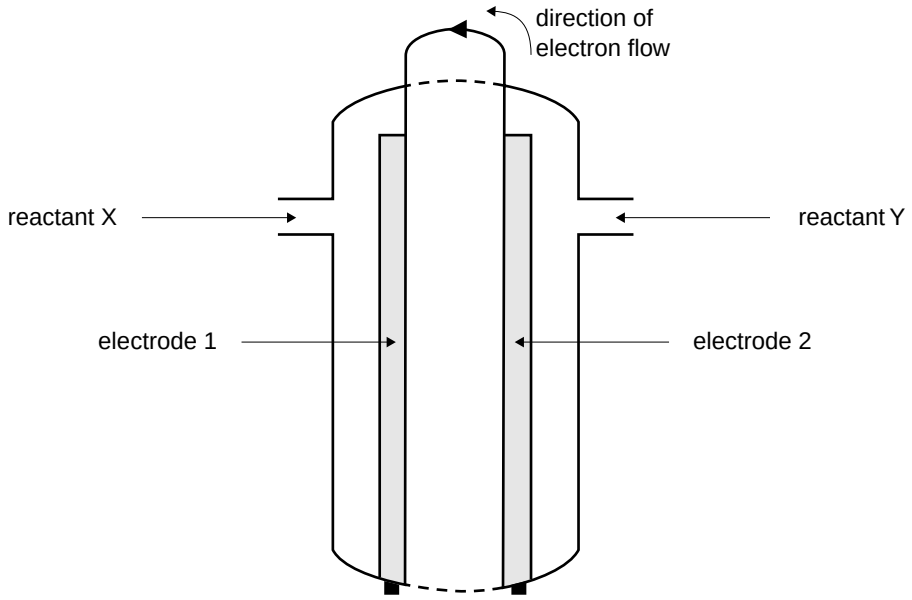
B. 25

C. 28

D. 40

Use the following information to answer Questions 3 and 4.

Fuel cells are electrochemical cells that convert chemical energy into electrical energy. The diagram below shows an alkaline hydrogen-oxygen fuel cell.



Question 3

The alternative that gives the correct polarity of electrodes 1 and 2 and the name of reactants X and Y is

	Electrode 1	Electrode 2	Reactant X	Reactant Y
A.	positive	negative	$O_2(g)$	$H_2(g)$
B.	positive	negative	$H_2(g)$	$O_2(g)$
C.	negative	positive	$O_2(g)$	$H_2(g)$
D.	negative	positive	$H_2(g)$	$O_2(g)$

Question 4

The reactions at the anode and cathode are respectively

	Anode reaction	Cathode reaction
A.	$H_2\,(g) \rightarrow 2H^+(aq) + 2e^-$	$O_2\,(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O\,(l)$
B.	$O_2\,(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O\,(l)$	$H_2\,(g) \rightarrow 2H^+(aq) + 2e^-$
C.	$O_2\,(g) + 2H_2O\,(l) + 4e^- \rightarrow 4OH^-\,(aq)$	$H_2\,(g) + 2OH^-\,(aq) \rightarrow 2H_2O(l) + 2e^-$
D.	$H_2\,(g) + 2OH^-\,(aq) \rightarrow 2H_2O(l) + 2e^-$	$O_2\,(g) + 2H_2O\,(l) + 4e^- \rightarrow 4OH^-\,(aq)$

Question 5

An electrolytic cell contains copper (II) chloride and magnesium nitrate dissolved in water so that the concentrations of $Cu^{2+}(aq)$ and $Mg^{2+}(aq)$ are each 1.0 M. An electric current is passed between the two inert electrodes of the cell.

The reaction at the negative electrode would be

A. $Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$

B. $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

C. $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$

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

Questions 6 and 7 refer to the electrolytic production of sodium and chlorine in the Down's cell.

Question 6

The electrolyte used in the Down's cell is

A. molten sodium chloride.

B. a molten mixture of sodium chloride and calcium chloride.

C. 1 M aqueous sodium chloride.

D. an aqueous mixture of 1 M sodium chloride and 1 M calcium chloride.

Question 7

The products, sodium and chlorine, are kept separate when they leave the cell because

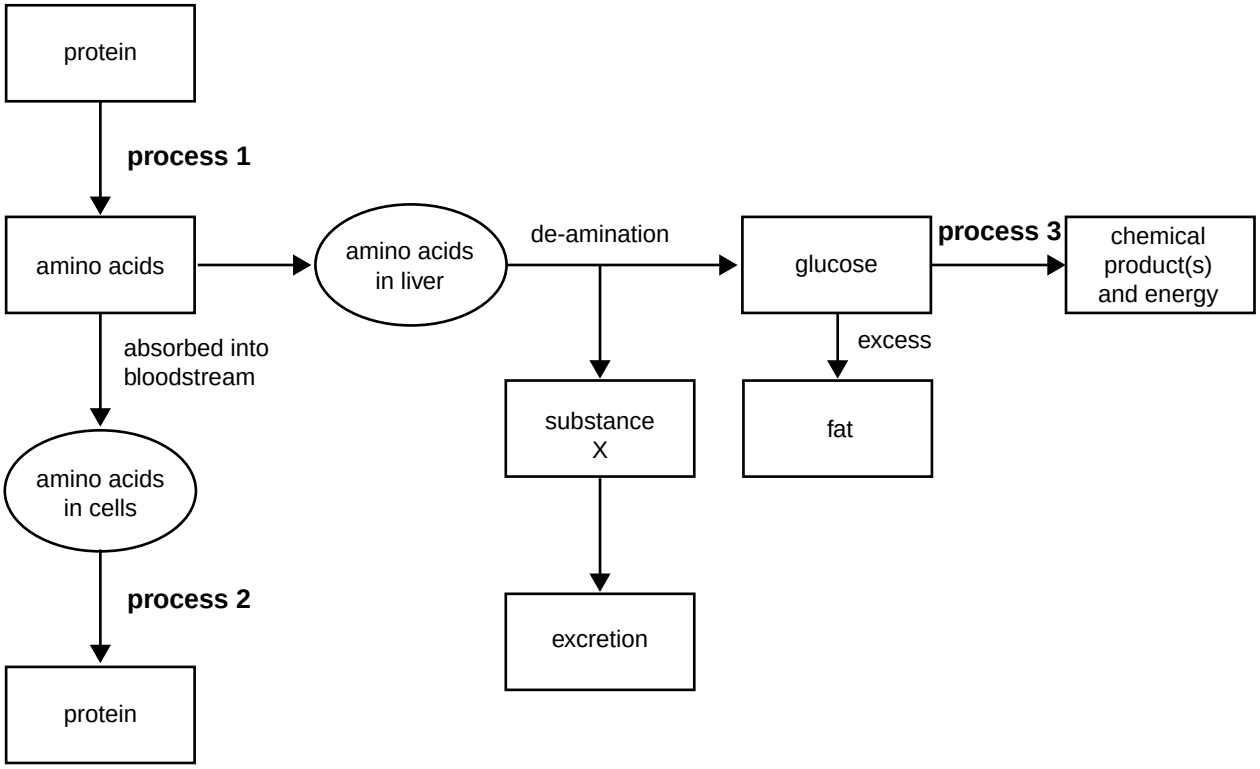
A. when mixed they undergo a spontaneous redox reaction.

B. the chlorine would dissolve in the molten sodium.

C. sodium is denser than chlorine.

D. chlorine is dangerous to handle whereas sodium is safe.

Use this flowchart to answer Questions 8 to 12.



Question 8

Which class of reaction occurs in process 1?

A. hydrolysis
B. oxidation
C. reduction
D. condensation

Question 9

Which class of reaction occurs in process 2?

A. hydrolysis
B. oxidation
C. reduction
D. condensation

Question 10

Which class of reaction occurs in process 3?

A. hydrolysis
B. oxidation
C. reduction
D. condensation

Question 11

Which one or more chemical product(s) result(s) from process 3?

A. CO_2 only

B. CO_2 and H_2O only

C. CO_2, H_2O and urea only

D. urea only

Question 12

Substance X has the formula

A. NH_2CH_2COOH

B. $C_6H_{12}O_6$

C. NH_2CONH_2

D. CO_2

Question 13

In order to manufacture proteins, plants need sources of carbon, hydrogen, oxygen and nitrogen. Most plants can obtain their nitrogen through absorption of

A. amino acids from the soil through their roots.

B. ammonium ions from the soil through their roots.

C. atmospheric nitrogen through their leaves.

D. atmospheric nitrogen oxides through their leaves.

Question 14

The fatty acid with the greatest degree of unsaturation is

A. $C_{18}H_{34}O_2$

B. $C_{24}H_{48}O_2$

C. $C_{18}H_{32}O_2$

D. $C_{20}H_{32}O_2$

Question 15

Common fuels are substances that, under the right conditions, can undergo

A. an exothermic oxidation process.

B. an endothermic oxidation process.

C. an exothermic reduction process.

D. an endothermic reduction process.

Question 16

In a mass spectrometer, the separation of ions in a magnetic field depends on their mass and charge. The path of which of the following ions would be affected **most** by the magnetic field in a mass spectrometer?

A. $^{63}Cu^+$

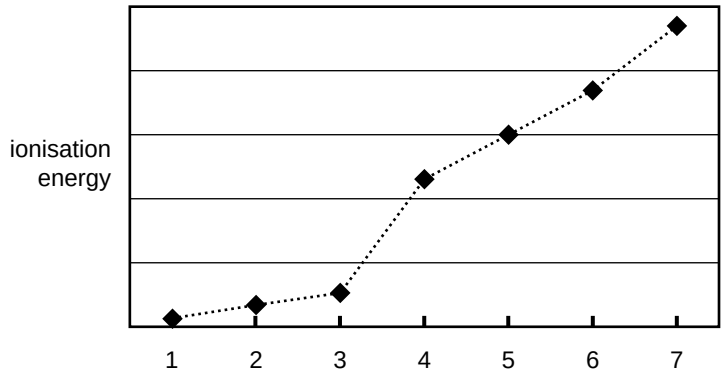
B. $^{65}Cu^+$

C. $^{63}Cu^{2+}$

D. $^{65}Cu^{2+}$

Question 17

The following graph shows the first to seventh ionisation energies of an element.



The element could be

A. boron.

B. nitrogen.

C. aluminium.

D. silicon.

Question 18

The property that is used as a basis for classifying elements into **groups** of the periodic table is

A. mass number.

B. atomic number.

C. number of electrons.

D. electron configuration.

Question 19

Consider the following nuclear equation

$$^{226}_{88}\text{Ra} \rightarrow \text{X} + {}^{222}_{86}\text{Rn}$$

In this equation, X represents

A. $^{1}_{0}\text{n}$

B. $^{1}_{0}\text{e}$

C. $^{4}_{2}\text{He}$

D. $^{1}_{1}\text{H}$

Question 20

When two protons and two neutrons come together to form a helium nucleus

A. mass is lost and converted to energy, which is released.

B. mass is gained from the energy put into the nuclear reaction.

C. mass is conserved but energy is required to force the reaction to occur.

D. mass is lost initially but it is then regained.

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

Specific instructions for Section B

Section B consists of seven short-answer questions numbered 1 to 7. A total of 51 marks is allocated for these questions. You should answer all of these questions. Section B is worth approximately 72 per cent of the marks available. You should therefore spend approximately 65 minutes on this section.

The marks allotted to each question are shown at the end of each question.

Questions must be answered in the spaces provided in this book.

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, $H_2(g)$; $NaCl(s)$.

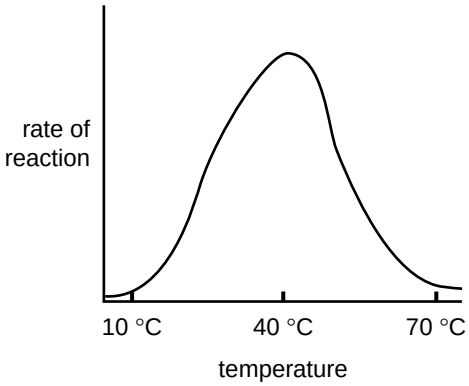
Question 1

Enzymes are an important group of proteins that act as catalysts in biochemical reactions.

a. Explain why the catalytic function of an enzyme molecule is dependent on the way the molecule is folded.

1 mark

b. The rate of reaction is affected by temperature. The graph below shows the rate of a reaction that uses an enzyme catalyst at different temperatures.



Explain why the reaction rate

i. increases in the temperature range between 10 ºC and 40 ºC

ii. decreases in the temperature range between 40 ºC and 70 ºC.

1 + 1 = 2 marks

c. Enzymes are polymers of amino acids, all of which have the same two functional groups.
Give the formulas of the two functional groups common to all amino acids as they would be found in an **acid** solution. Use the spaces below for the formulas.

2 marks

Total 5 marks

Question 2

The heat of combustion of methanol is given below.

$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$ $\Delta H = -1454 \text{ kJ mol}^{-1}$

a. Calculate the energy released, in kJ, when 1.00 g of methanol reacts according to the above equation.

3 marks

b. Food provides energy to the human body. A calibrated bomb calorimeter can be used to determine, in the laboratory, the energy content of food.

i. A student calibrated a bomb calorimeter by burning 1.00 g of methanol (CH_3OH) in it. The student found that the temperature of the water inside the calorimeter rose from 15.0 °C to 26.5 °C.

Calculate the calibration factor for this bomb calorimeter.

ii. To find the energy content of a sample of dried bread, 2.70 g of the dried bread was burnt in the calorimeter calibrated above. The temperature of the water surrounding the bomb rose by 20.5 °C.

Calculate the heat energy, in kJ g^{-1}, of the bread.

iii. A possible source of error in this experiment is that the bread was not completely dry when weighed and burned in the calorimeter. Would the calculated energy content of the bread be **higher** or **lower** than the correct value if the bread was not completely dry?

Explain your answer.

iv. Another source of error is that the actual mass of the methanol used in the calibration process was 0.90 g instead of the 1.00 g recorded. Explain the effect this would have on

- the calculated calibration factor of the calorimeter

  and

- the calculated energy content of the bread.

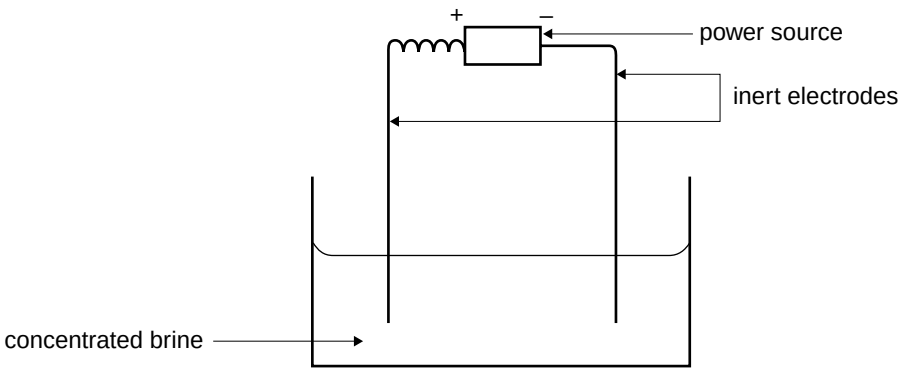
v. The energy provided to the body by bread is slightly less than the calculated amount obtained from the bomb calorimeter. Apart from experimental error, give a reason to account for this difference.

2 + 2 + 2 + 3 + 1 = 10 marks

Total 13 marks

Question 3

The figure below shows a simple arrangement for the electrolysis of concentrated brine solution (NaCl(aq)) to produce chlorine gas ($Cl_2(g)$).



a. Give an equation for the reaction at the

i. positive electrode (anode) _____

ii. negative electrode (cathode) _____

1 + 1 = 2 marks

b. In industry, the production of Cl_2 gas can be carried out using either a diaphragm cell or a membrane cell. The diaphragm and membrane serve a similar purpose in these cells.

i. What is this purpose?

_____

_____

ii. Give one advantage of selective membrane technology over diaphragm technology in the electrolytic production of chlorine.

_____

_____

1 + 1 = 2 marks

c. Besides Cl_2 gas, the diaphragm cell might be used for the industrial production of two other useful chemicals. Name these.

_____

2 marks

Total 6 marks

Question 4

A lead-acid battery is made up of six cells connected in series. When the battery is providing energy, the reactions occurring at the electrodes of a single cell are

$$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$$

$$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$$

a. **i.** Give an equation for the net reaction that occurs while a lead-acid battery is providing energy.

_____

_____

ii. Give the formula of the oxidant **and** the formula of the reductant in the above reaction.

oxidant _____

reductant _____

1 + 2 = 3 marks

b. A particular lead-acid battery delivers a current of 3.50 A for 2.00 minutes at a potential difference of 12.0 V.

i. What amount, in mole, of PbO_2 will be used up within the whole battery of six cells?

_____

_____

_____

_____

ii. What mass, in gram, of $PbSO_4$ will be deposited in each **one** of the six cells?

_____

_____

_____

_____

_____

_____

iii. How much energy, in joule, could be obtained in this situation?

_____

_____

_____

3 + 3 + 1 = 7 marks

Total 10 marks

SECTION B – continued

TURN OVER

Question 5

Chemical equations are useful ways to describe chemical reactions. For each of the reactions described below, write

i. a chemical equation

and

ii. answer the question about the reaction where applicable.

a. Photosynthesis is one of the key reactions in the carbon cycle.

Equation _____

Is this reaction exothermic or endothermic? _____

2 marks

b. Transition metals, such as chromium, can be found in several different oxidation states. The dichromate ion, $Cr_2O_7^{2-}(aq)$ is a strong oxidant which is reduced to chromium (III) ions, $Cr^{3+}(aq)$ in acid solution. Write a half equation for the reduction of the $Cr_2O_7^{2-}(aq)$ to $Cr^{3+}(aq)$ in acid solution.

Half equation _____

What is the oxidation state of chromium in the dichromate ion? _____

Why can transition metals such as chromium exist in several different oxidation states?

_____

_____

_____

Transition metals can form complex ions. Write an equation for the formation of a transition metal complex from a transition metal ion of your choice.

_____

1 + 1 + 1 + 1 = 4 marks

Total 6 marks

Question 6

A chemistry text contains the following information.

> Mendeleev...rejected the concept of the ion as an electrically charged molecular fragment. He refused to recognise the reality of the electron. He was opposed in general to linking chemistry with electricity and preferred to link it with physics as the science of mass.
> (*Chemistry About You* – Smith & Dwyer, Nelson, 1988)

Even though Mendeleev's understanding of both chemistry and physics was so obviously in serious error, he was still able to develop one of the first satisfactory periodic tables.

State the two principles on which Mendeleev's version of the periodic table were based.

Explain how Mendeleev's principles differ from the principles on which the modern periodic table is based.

Why do you think Mendeleev's attempt was so successful?

2 + 1 + 1 = 4 marks

CONTINUED OVER PAGE

Question 7

Consider the following elements of the third period of the periodic table.

Na, Mg, Al, Si, P, S, Cl

a. In general, the first ionisation energy increases across the period from Na to Cl.

i. Explain what is meant by **first ionisation energy.**

ii. Why does the first ionisation energy increase from Na to Cl?

1 + 2 = 3 marks

b. **i.** How do the oxidising and reducing properties of the elements change from Na to Cl?

oxidising properties

reducing properties

ii. Explain what is meant by the term ‘electronegativity’.

Account for the change in oxidising properties from Na to Cl in terms of the relative electronegativities of these elements.

2 + 1 + 1 = 4 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

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)

END OF DATA SHEET