VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2006

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

									Letter
Figures									
Words									

CHEMISTRY

Written examination 2

Thursday 9 November 2006

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	9	9	58
			Total 78

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers and 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 21 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

Which one of the following is **not** an important energy conversion in a coal-fired power station?

A. chemical energy of coal → thermal energy of steam
B. thermal energy of steam → mechanical energy of turbine
C. mechanical energy of turbine → chemical energy of steam
D. mechanical energy of turbine → electrical energy from generator

Question 2

Sources of energy other than fossil fuels are increasingly being used by power companies to generate electricity for domestic use.

Which one of the following energy sources is **not** available in Australia for domestic purposes?

A. wind power
B. nuclear fusion
C. solar energy
D. hydroelectricity

Question 3

Hydrogen iodide (HI) is formed from the reaction of the elements hydrogen and iodine

$$H_2(g) + I_2(g) \rightarrow 2HI(g); \quad \Delta H = +52 \text{ kJ mol}^{-1}$$

When two moles of HI decompose

A. 52 kJ of energy is released.
B. 52 kJ of energy is absorbed.
C. 104 kJ of energy is released.
D. 104 kJ of energy is absorbed.

Questions 4 and 5 refer to the following information.

A galvanic cell is constructed from the following half cells, at 25°C.

	electrode	**half cell solution (all concentrations 1.0 M)**
half cell 1	silver	colourless solution of $AgNO_3$
half cell 2	copper	blue-coloured solution of $CuCl_2$

The half cells are connected with a salt bridge and the electrodes are joined by a wire.

Question 4

Which one of the following is likely to occur?

A. The copper electrode will increase in mass.

B. Bubbles of gas will form at the copper electrode.

C. The concentration of silver ions in solution will increase.

D. The blue colour of the copper (II) chloride solution will become more intense.

Question 5

When the current is flowing

A. the anode is positive and the cathode is negative.

B. an oxidation reaction occurs at the positive electrode.

C. anions in the salt bridge move towards the negative electrode.

D. electrons travel in the external circuit from the cathode to the anode.

Question 6

Natural gas can be burnt in a power station to provide electrical energy. Alternatively, natural gas can be fed into a fuel cell for electricity generation.

At the present time, which one of the following best compares the efficiency and cost of generating electrical energy by these two methods in a city like Melbourne?

	efficiency of fuel cell	**cost per kJ of electricity from fuel cell**
A.	higher	lower
B.	higher	higher
C.	lower	lower
D.	lower	higher

Question 7

Tin metal is electroplated onto sheets of iron using a tin anode and a well-stirred solution containing Sn^{2+} ions.

During this process

A. the anode increases in mass.

B. Sn^{2+} ions move towards the cathode.

C. the concentration of Sn^{2+} in the solution decreases.

D. the concentration of Sn^{2+} in the solution increases.

Question 8

The passage of 0.019 faradays of electricity through a molten chromium compound yields 0.50 g of chromium metal.

The oxidation number of chromium in the compound is likely to be

A. +2

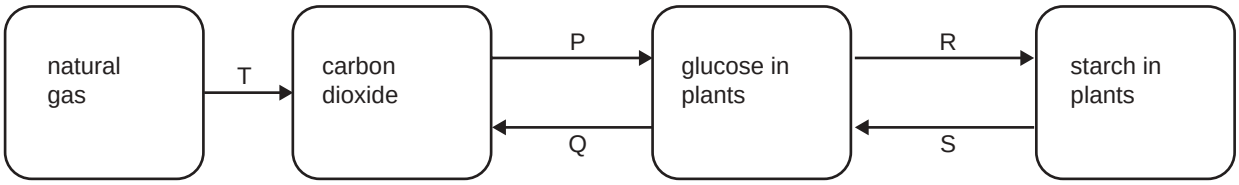
B. +3

C. +4

D. +6

Questions 9 and 10 refer to the following information.

A simplified section of the carbon cycle is shown below.



Question 9

Carbon atoms are oxidised in reaction(s)

A. Q only.

B. S and Q only.

C. Q and T only.

D. Q, R and T only.

Question 10

Reactions in which water is a product are

A. P and R.

B. Q and S.

C. P, S and T.

D. Q, R and T.

Question 11

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

A. H_2NCH_2COOH

B. $H_2NCH(CH_2SH)COOH$

C. $H_2NCH_2CH(CH_3)COOH$

D. $H_2NCH(CH_2COOH)COOH$

Question 12

Humans obtain all of their energy requirements from the food they eat. The amount of energy in food can be measured using a bomb calorimeter.

The following are steps, in random order, that are taken to determine experimentally the energy content of a sample of a food, using a bomb calorimeter.

1. Measure the rise in temperature
2. Fill the calorimeter with water and wait until the temperature has reached a steady value
3. Accurately weigh the sample of the food and place it inside the sealed compartment or 'bomb' in the presence of excess oxygen
4. Measure the rise in temperature again
5. Pass a measured amount of electrical energy into the system
6. Ignite the sample with electrical ignition wires

Which one of the following alternatives best presents an appropriate sequence of procedures?

A. 5, 1, 3, 2, 4, 6

B. 2, 3, 1, 5, 6, 4

C. 3, 2, 5, 1, 6, 4

D. 3, 6, 1, 2, 5, 4

Question 13

When adults consume more food than their energy requirements, the extra energy is stored by the body.

In adults this excess energy is usually stored as

A. glucose and fats.

B. glycogen and fats.

C. starch and glucose.

D. protein and carbohydrates.

Question 14

Amylase is an enzyme that specifically digests starch in humans.

A major product of this starch hydrolysis reaction is

A. maltose.

B. glycogen.

C. cellulose.

D. glycerol.

Question 15

The function of a protein is dependent on its three-dimensional structure. This structure can be disrupted, denaturing the protein.

Which of the following changes could cause this denaturing?

I the addition of a strong acid

II the addition of a strong base

III a significant increase in temperature

A. I only

B. I and II only

C. III only

D. I, II and III

Question 16

Which one of the following alternatives lists the atoms of aluminium, calcium, sulfur and chlorine in order of increasing electronegativity?

A. (lowest) Al, S, Cl, Ca (highest)

B. (lowest) Ca, Al, S, Cl (highest)

C. (lowest) Cl, S, Al, Ca (highest)

D. (lowest) S, Ca, Al, Cl (highest)

Question 17

Which one of the following alternatives lists the atoms of chlorine, fluorine, magnesium and potassium in order of increasing atomic radius?

A. (smallest) K, Mg, Cl, F (largest)

B. (smallest) F, Mg, Cl, K (largest)

C. (smallest) K, F, Mg, Cl (largest)

D. (smallest) F, Cl, Mg, K (largest)

Question 18

Which one of the following alternatives lists the atoms of chlorine, magnesium, neon and phosphorus in order of increasing first ionisation energy?

A. (smallest) Mg, P, Cl, Ne (largest)

B. (smallest) Ne, Cl, P, Mg (largest)

C. (smallest) Cl, Mg, Ne, P (largest)

D. (smallest) P, Mg, Cl, Ne (largest)

Question 19

When Dimitri Mendeleev developed the periodic table he left gaps for as yet undiscovered elements.

On the basis of the position of these gaps and in relation to these undiscovered elements, Mendeleev was able to predict

A. their electron configurations.

B. the occurrence of their isotopes.

C. many of their physical properties.

D. their atomic numbers and mass numbers.

Question 20

When the oxide Cl_2O_7 is added to water a reaction takes place which is **not** a redox process.

The product(s) of the reaction could be

A. $HClO_4$

B. HOC1

C. Cl_2 and O_2

D. HCl and O_2

END OF SECTION A
TURN OVER

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

a. In 1804 the atomic theory of John Dalton was first published. Two of the ideas expressed in his theory are listed below. How does our current understanding of atomic theory differ from each of these two ideas?

i. All matter is composed of tiny, indivisible particles called atoms.

ii. Atoms of the same element are identical in every respect.

1 + 1 = 2 marks

b. In 1913 the Danish physicist Niels Bohr proposed a theory to explain the emission spectrum of hydrogen.

His theory stated that

- the electron in the hydrogen atom circled the nucleus in certain fixed orbits
- each orbit was of a certain energy level
- orbits closer to the nucleus were of lower energy than those further away.

i. How does this theory explain that the emission spectrum of hydrogen consists of a set number of discrete lines?

ii. State one way in which our present understanding of the electron structure of atoms in general differs from that proposed by Bohr for the hydrogen atom.

2 + 1 = 3 marks

Total 5 marks

Question 2

A uranium nucleus can undergo nuclear fission when bombarded with a neutron. In one such fission reaction, two neutrons are released and two different new nuclei form. One is a zirconium nucleus, $^{97}_{40}Zr$, and the other is a nucleus of element X, as shown in the following equation.

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow X + {}^{97}_{40}Zr + 2\,{}^{1}_{0}n$$

a. How many neutrons are present in a nucleus of $^{235}_{92}U$? _____

1 mark

b. To which section of the periodic table does uranium belong? _____

1 mark

c. What is the

i. chemical symbol for element X _____

ii. mass number of the above isotope of element X? _____

1 + 1 = 2 marks

d. Zirconium, Zr, is placed in the second series of transition elements. Given that the properties of the elements in the second transition series are similar to those in the first transition series, predict **two** properties of the element zirconium.

_____

_____

_____

2 marks

Total 6 marks

Question 3

a. The following information refers to the isotopes of copper and was collected by using a mass spectrometer.

Isotope	**Relative isotopic mass**
^{63}Cu	62.93
^{65}Cu	64.93

Given that the relative atomic mass of copper is 63.54, calculate the percentage abundance of the ^{63}Cu isotope.

2 marks

b. **i.** The atomic number of nickel is 28.

Write the electron configuration, in terms of shells and subshells, of the nickel atom in its ground state.

ii. Write the electron configuration, in terms of shells and subshells, of the nickel (II) ion in its ground state.

iii. The nickel (II) ion forms a complex ion with six molecules of ammonia (NH_3). Sketch the structure of this complex ion, clearly showing the position and the orientation of the ammonia molecules around the Ni^{2+} ion.

1 + 1 + 1 = 3 marks

c. Nickel and copper are both found in the first transition series of the periodic table. Explain why there are exactly 10 elements in each of the series of transition metals.

_____

_____

_____

1 mark

Total 6 marks

Question 4

The calibration factor of a calorimeter can be determined by performing in the calorimeter a reaction which produces a known quantity of energy, and measuring the rise in temperature.

In one experiment, 50.0 mL of 0.400 M lead nitrate was added to 50.0 mL of 0.760 M potassium iodide in a solution calorimeter encased in a polystyrene insulating jacket. The mixture was stirred continuously and the temperature rose from 18.42°C to 20.50°C as the following reaction occurred.

$$Pb(NO_3)_2(aq) + 2KI(aq) \rightarrow PbI_2(s) + 2KNO_3(aq); \ \Delta H = -49.0 \text{ kJ mol}^{-1}$$

a. Calculate the amount, in mole, of lead nitrate.

1 mark

b. Calculate the amount, in mole, of potassium iodide.

1 mark

c. Calculate the energy released by the reaction in the calorimeter, in J.

2 marks

d. Calculate, to an appropriate number of significant figures, the calibration factor of the calorimeter and its contents, in $J°C^{-1}$.

2 marks

e. Two errors that might have occurred during this experiment are listed below. For each error, indicate the likely effect on the calculated calorimeter factor by placing a tick in the appropriate box.

Error	**Calculated calibration factor too low**	**No effect on calculated calibration factor**	**Calculated calibration factor too high**
i. The concentration of the lead nitrate solution had been incorrectly recorded and was actually 0.410 M			
ii. The calorimeter was not placed in its polystyrene jacket			

iii. Give an explanation for your answer to part **ii.** above.

1 + 1 + 1 = 3 marks

Total 9 marks

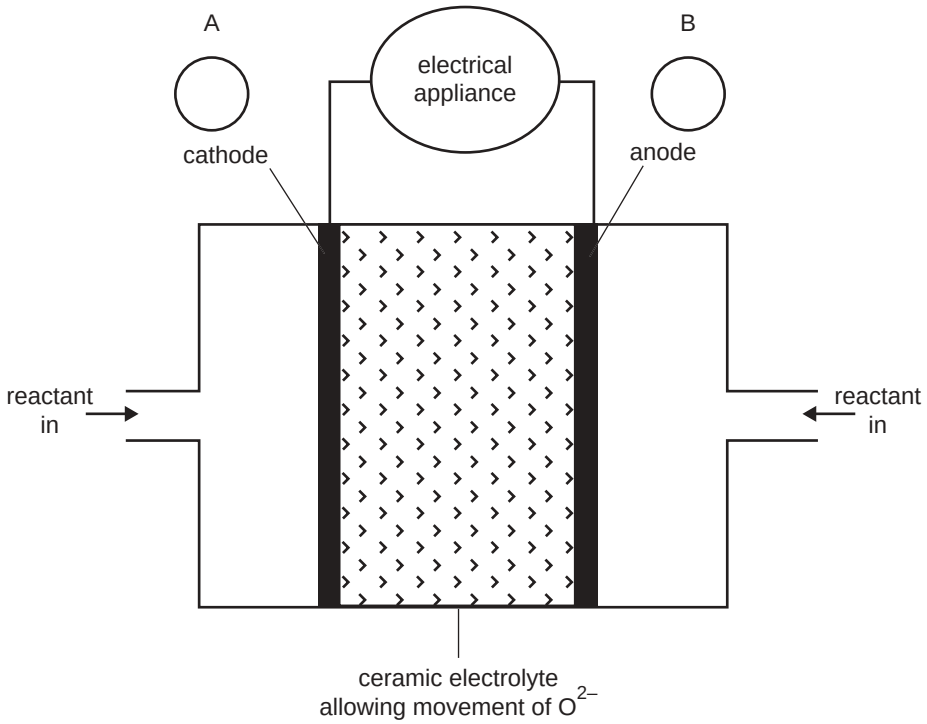
Question 5

An Internet site reporting the latest developments in fuel cell technology describes a cell that uses a solid ceramic material as the electrolyte and hydrogen gas and oxygen gas as the reactants.

Key features of this cell are

- water is the only product from the cell reaction
- the ceramic material allows the movement of oxide ions (O^{2-})
- the reaction at the anode is $H_2(g) + O^{2-}(\text{in ceramic}) \rightarrow H_2O(l) + 2e^-$
- operation at very high temperatures of over 1000°C means that precious metal catalysts are not required.

A representation of the cell providing electricity for an appliance is shown in the diagram below.



a. What distinguishes a fuel cell from a galvanic cell such as a dry cell or lead-acid battery?

_____

_____

1 mark

b. On the diagram above

i. in **circles A and B**, indicate the polarity of the cathode and anode

ii. show, by using an arrow, the direction of electron flow in the external circuit.

1 + 1 = 2 marks

c. Write an equation for each of the following reactions. You are not required to show states in these two equations.

i. the overall cell reaction

_____

ii. the reaction at the cathode

_____

1 + 1 = 2 marks

d. A ceramic fuel cell delivers a current of 0.500 A for 10.0 minutes at a potential of 0.600 volts.

i. How much electrical energy, in joules, would be provided by the cell?

ii. Calculate the charge, in coulomb, produced by the cell.

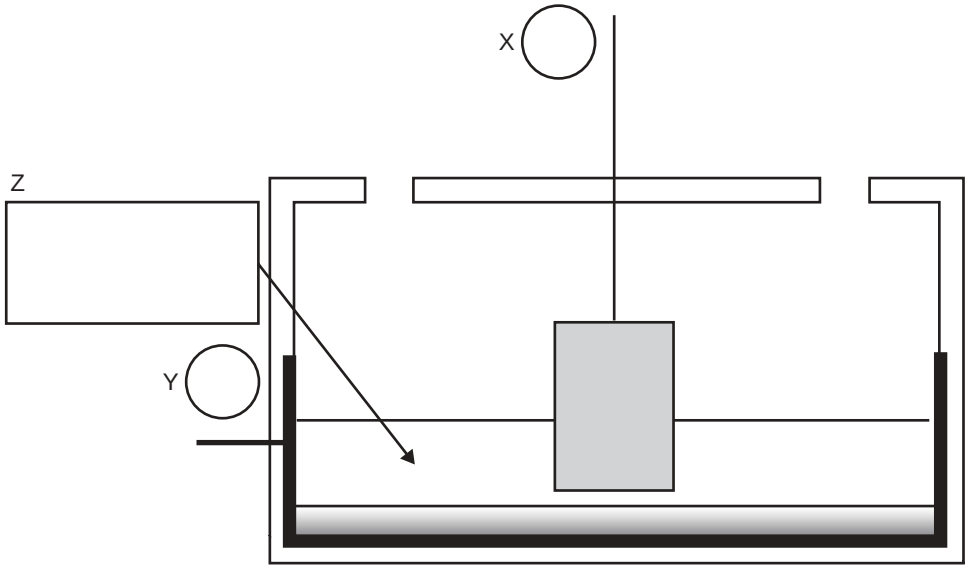
iii. If this particular cell operated at 60.0% efficiency, what amount of hydrogen gas (H_2), in mole, would be consumed by the fuel cell?

1 + 1 + 3 = 5 marks

Total 10 marks

Question 6

The simplified diagram below shows the Hall Cell that is used for the industrial production of aluminium.



a. **In circles X and Y** in the diagram, show the polarity of the electrodes.

1 mark

b. In the Hall Cell, the electrolyte consists of alumina mixed with another compound. **In box Z**, write the name or the formula of this compound.

1 mark

c. Write a half equation for the reaction that occurs at the

i. anode

_____

ii. cathode.

_____

1 + 1 = 2 marks

d. Suppose the electrolyte was replaced with an aqueous solution of $Al(NO_3)_3$ at 25°C. Write an equation for the half reaction that would occur at the cathode.

_____

_____

1 mark

Total 5 marks

Question 7

Give concise explanations in answer to each of the following.

a. Calcium chloride is added to the molten sodium chloride electrolyte in the Downs Cell for the production of sodium. Explain why calcium metal is not produced in the cell.

1 mark

b. An asbestos barrier once used in commercial diaphragm cells to separate the chemicals produced by the electrolysis of concentrated salt water is replaced with a plastic membrane in modern cells. Give one advantage of using a plastic membrane instead of asbestos.

1 mark

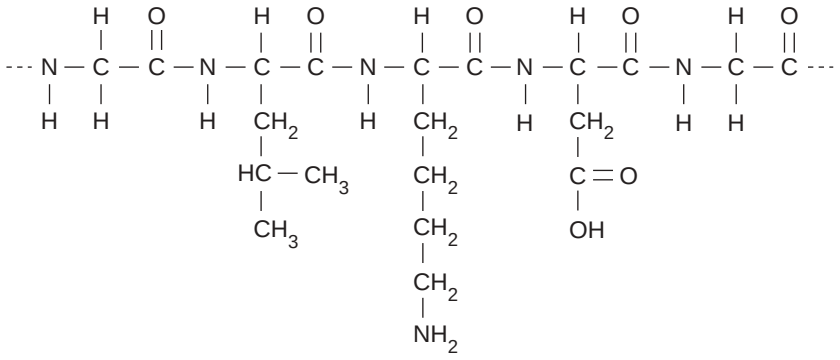
c. The heat of combustion of plant-based foodstuffs as determined by calorimetry is very often an overestimate of the energy available when the food is eaten and digested by humans. Give one reason why this might be the case.

1 mark

Total 3 marks

Question 8

The structure of a section of a protein chain is shown in the diagram below.



a. In water, protein molecules often adopt a roughly spherical tertiary structure in which the side chain groups play an important role in influencing shape and solubility.

i. **On the above structure** of the portion of the protein chain, **circle** the side chain group that is hydrophobic.

ii. In general, would you expect hydrophobic groups to be in the interior or to be on the external surface of water soluble proteins? Explain your reasoning.

1 + 1 = 2 marks

b. During digestion, the section of the protein shown above undergoes hydrolysis to form amino acids.

i. When this section of the protein is hydrolysed, one of the amino acids formed has a carbon to nitrogen ratio of 3:1.
In **box A** below, draw the structure of this amino acid.

ii. In **box B** below, draw the structural formula of this same amino acid as it would most likely exist at pH 2.

A	**B**

1 + 1 = 2 marks

c. When vegetables such as potatoes are cut and exposed to air, a browning reaction takes place. This is caused by the enzyme, polyphenol oxidase, interacting with oxygen and polyphenols present in the vegetable. The browning reaction may be prevented by placing the vegetable in boiling water for a short time. When removed from the boiling water and cooled, browning no longer takes place. Explain the chemical basis of this observation.

_____

_____

_____

1 mark

d. Living things require a source of nitrogen in order to form proteins. Plants obtain their nitrogen from nitrogen-containing ions present in the soil.

Give the **formula** for an ion present in the soil in which nitrogen has an oxidation number of **+5**.

_____

1 mark

Total 6 marks

Question 9

a. **i.** A long chain carboxylic acid can be represented by the general formula RCOOH where R represents a hydrocarbon group.

In the space below, show the structure of a fat formed by the reaction between glycerol and three molecules of RCOOH. Clearly show the **structure of all ester groups** in the fat.

ii. Palmitic acid ($C_{16}H_{32}O_2$) and oleic acid ($C_{18}H_{34}O_2$) are both long chain carboxylic acids.

Which one of them is classified as an **unsaturated** carboxylic acid?

_____

2 + 1 = 3 marks

b. Unsaturated fats can be converted into saturated fats by reaction with hydrogen gas in the presence of a metallic catalyst. In one such conversion, 2.50 mole of an unsaturated fat is converted to a saturated fat by reaction with 15.0 g of H_2 gas.

Calculate the number of carbon to carbon double bonds present in a molecule of the unsaturated fat.

_____

_____

_____

_____

2 marks

c. The heat of combustion of palmitic acid ($C_{16}H_{32}O_2$) may be determined by burning it in a bomb calorimeter in the presence of excess oxygen.

Write a balanced equation for the complete combustion (burning) of palmitic acid in the presence of excess oxygen.

_____

_____

2 marks

d. Vitamin C is an antioxidant that is often added to margarine to prevent it from becoming rancid. Explain how vitamin C acts as an antioxidant.

_____

_____

1 mark

Total 8 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