Student No. _____

Barker College

2001
TRIAL HIGHER SCHOOL CERTIFICATE

Chemistry

Staff Involved:

- KHW*
- KJB
- ASM
- JRH

72 copies

PM FRIDAY 10 AUGUST

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Board-approved calculators may be used
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your Barker Student Number on ALL answer pages

Section I Pages 2 - 6

Total marks (15)
- Indicate all answers on the Answer Sheet provided
- Allow about 25 minutes for this section

Section II Pages 7 - 18

Total marks (60)
- Attempt ALL questions
- Indicate all answers in the spaces provided on the Answer Sheets
- Allow about 110 minutes for this section

Section III Pages 19 - 22

Total marks (25)
- Attempt ALL questions
- Indicate all answers in the spaces provided on the Answer Sheets
- Allow about 45 minutes for this section

Section I

Total marks (15)

Allow about 25 minutes for this section

Attempt ALL questions

Use the multiple-choice answer sheet

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

(A) ○ (B) ● (C) ○ (D) ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

(A) ● (B) ⊗ (C) ○ (D) ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.

correct ←

(A) ⊗ (B) ⊗ (C) ○ (D) ○

6. Which of the following compounds, when mixed with distilled water, exists as an equilibrium mixture with its ions?

(A) Hydrochloric acid
(B) Sulfuric acid
(C) Nitric acid
(D) Ethanoic acid

7. The relationship between an element's position on the periodic table and the acidic or basic nature of its oxide is best described by which one of the following statements?

(A) Elements with the lowest first ionisation energy in any period usually form acidic oxides.
(B) Elements that have medium to high melting points are more likely to make acidic oxides.
(C) Elements that form covalent bonds are more likely to make acidic oxides.
(D) Elements which are excellent conductors of electricity usually make acidic oxides.

8. The bottle of soda water illustrated represents an equilibrium system that can be described by the equation below.

$$CO_{2(g)} + H_2O_{(\ell)} \rightleftharpoons H_2CO_{3(aq)}$$

Which statement best describes what happens immediately the lid is taken off?

(A) As pressure decreases the equilibrium between $CO_{2(aq)}$ and $CO_{2(g)}$ shifts towards $CO_{2(g)}$.
(B) The pressure increases and the equilibrium moves to make more CO_2 in the solution.
(C) The reaction moves to the right increasing $[H_2CO_3]$, reducing $[CO_2]$ and making the soda water flat.
(D) As the concentration of H_2CO_3 decreases more CO_2 dissolves making the soda water flat.

9. Which of the following is the conjugate base of $H_2PO_4^-$?

(A) H_2PO_4
(B) H_3PO_4
(C) HPO_4^{2-}
(D) PO_4^{3-}

10. Which of the following reactions shows the transfer of a proton?

(A) Neutralisation of hydrochloric acid by potassium hydroxide.
(B) Oxidation of magnesium to form magnesium oxide.
(C) Reduction of silver ions to form silver metal.
(D) Combustion of butane to form carbon dioxide and water.

11. Buffered solutions can withstand the addition of excess acid or base without changing pl Which of the following substances would need to be added to 100 mL of 0.2 M ethanoic make it a buffered solution?

(A) 100 mL of 0.2 M sodium ethanoate.

(B) 100 mL of 0.2 M ammonia.

(C) 100 mL of 0.2 M sodium hydroxide.

(D) 100 mL of 0.2 M distilled water.

12. Water molecules can form a stable bond with H^+. What sort of bond links the water mole with the H^+ ion?

(A) Hydrogen bond
(B) Ionic bond
(C) Covalent bond
(D) Metallic bond

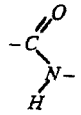
13. Ammonium chloride $(NH_4C\ell)$ is a white water soluble solid. The pH of 1 mol L^{-1} solutio ammonium chloride is 4.6 Which ion is present in the largest concentration in this solution

(A) Chloride ions
(B) Hydrogen ions
(C) Ammonium ions
(D) Hydroxide ions

14. Which of the following diagrams represents the alkanoic acid functional group?

(A) 

(B) 

(C) 

(D) 

15. A student set up a Galvanic cell including a voltmeter. He discovered that his measured cell potential was far less than the theoretical potential calculated from a table of standard reduction potentials. Which of the following would be a plausible explanation for this?

(A) His electrodes were not inert.

(B) His electrolyte was at a concentration less than 1 mol L^{-1}.

(C) His cell voltage was not measured at STP.

(D) His external power source was fluctuating.

Student No. _____

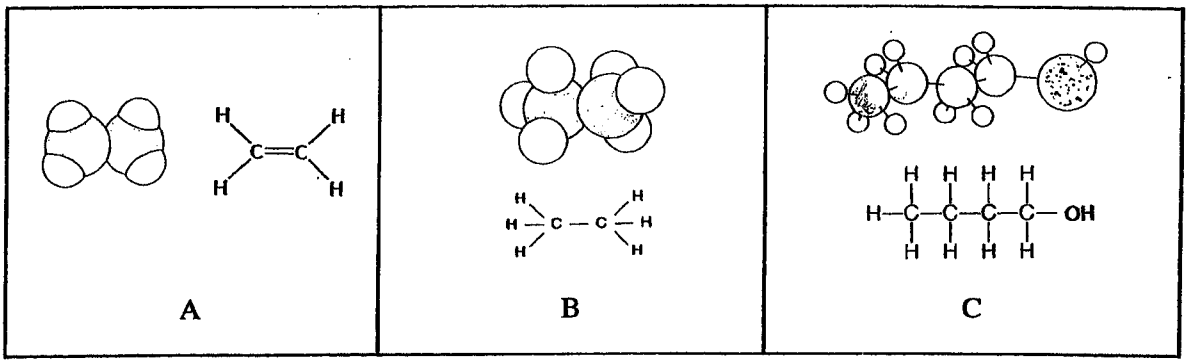
Section II
Total marks (60)
Attempt ALL questions
Allow about 110 minutes for this section

Use the spaces provided on the paper

Marks

Question 16 [6 marks]

The following illustrations represent the molecules of five carbon compounds that are important as sources of energy or raw materials for the production of other materials.



(a) State the systematic name for compound A and describe a simple laboratory test to distinguish it from compound B.

Compound A: _____ **1**

Laboratory test: _____

_____

_____

_____ **1**

Question 16 continued over page

Student No. _____

Marks

(b) From the compounds above, identify, by letter, the compound that shows the following property. Justify your choice for (i), (ii) and (iii) only.

(i) The most water soluble compound: _____

Reason: _____

_____ **1**

(ii) The compound with the highest boiling point: _____

Reason: _____

_____

_____

_____ **1½**

(iii) The compound which would make addition polymers: _____

Reason: _____

_____ **1**

(iv) The compound which would give the lowest heat of combustion: _____ **½**

Student No. _____

Marks

Question 17 [5 marks]

Chlorine is used for the manufacture of $C_2H_3C\ell$, a monomer that undergoes **addition** polymerisation.

(a) Draw the full structural formula for $C_2H_3C\ell$

1

(b) Give the systematic name for the monomer $C_2H_3C\ell$.

_____

_____ 1

(c) Draw the structural formula of the polymer that is produced from $C_2H_3C\ell$ with at least three monomer units and name it using the common name.

_____ 1

(d) In terms of its **structure** and **properties**, evaluate the usefulness of this polymer for garden hoses and water pipes.

_____

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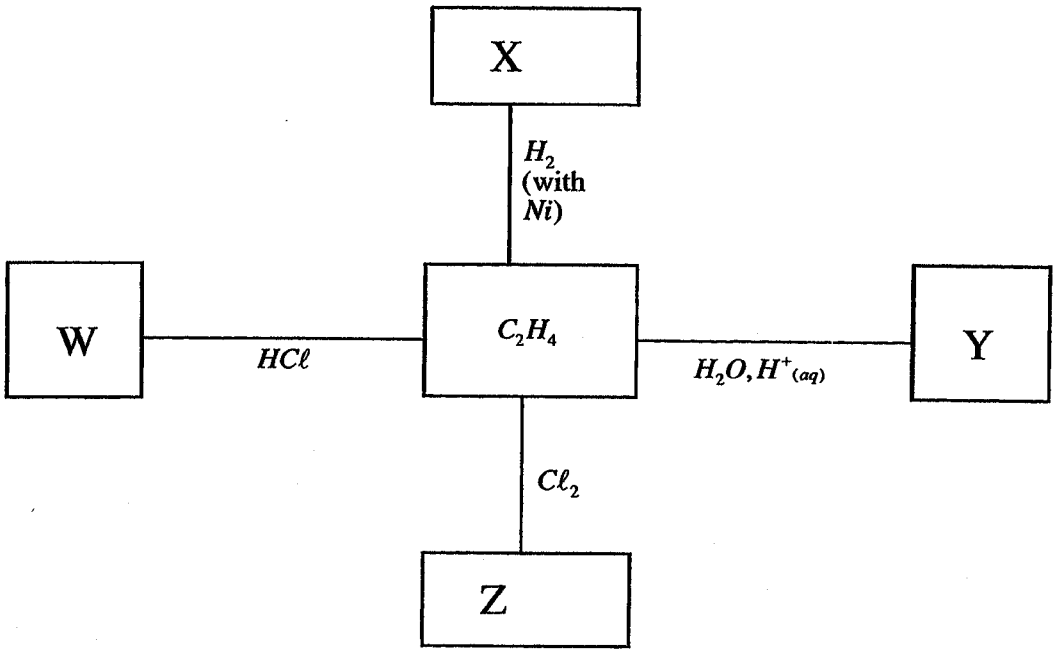
_____ 2

Student No. _____

Marks

Question 18 [10 marks]

The diagram below shows the reactions of the hydrocarbon C_2H_4.



The products of these reactions are represented by the letters W, X, Y, Z.

(a) Name the raw material from which C_2H_4 is currently obtained.

_____ **1**

(b) Identify and describe the process by which it is obtained.

_____

_____

_____ **2**

(c) State the systematic name and write the structural formula for the product Z.

_____

_____ **1**

Question 18 continued over page

Student No. _____

Question 18 (Continued)

Marks

(d) Explain the use of *Ni* in the production of X.

_____

_____

_____ **1**

(e) The product Y is predicted to be a future alternative fuel. Name and describe the biochemical process which produces Y from glucose. Use relevant equations and state the necessary conditions for this process to occur.

_____

_____

_____

_____

_____

_____ **3**

(f) Evaluate the **present** usefulness of cellulose as a raw material for the production of compound Y.

_____

_____

_____

_____

_____

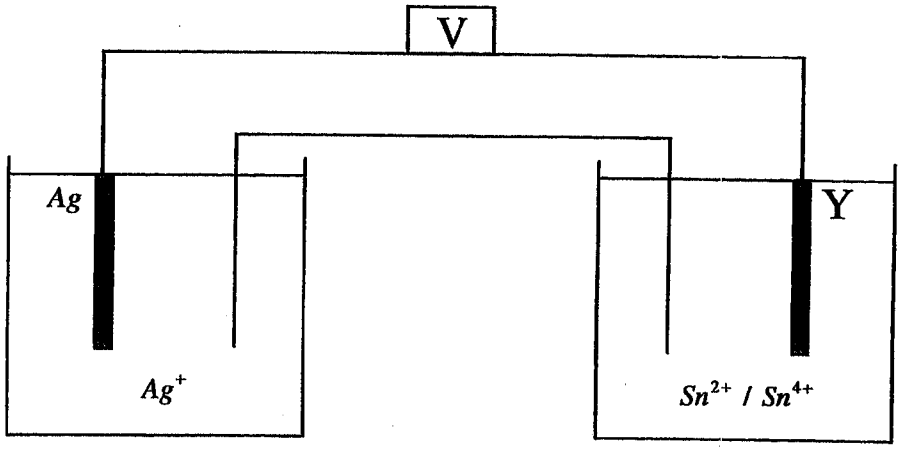
_____ **2**

Student No. _____

Marks

Question 19 [4 marks]

An HSC chemistry student is investigating possible new power sources and constructs an electrochemical cell from two standard half-cells using $Ag^{+}_{(aq)} / Ag_{(s)}$ and $Sn^{4+}_{(aq)} / Sn^{2+}_{(aq)}$, as in the diagram below.



(a) Using arrows and labels clearly indicate the direction of electron flow and migration of ions. **1**

(b) Write the equation for the reaction that occurs at the anode.

_____ **1**

(c) Describe **TWO** factors that would have to be considered when selecting an appropriate chemical for the salt bridge.

_____

_____ **1**

(d) Showing all steps in your working calculate the maximum EMF that this experimental cell could produce.

_____

_____

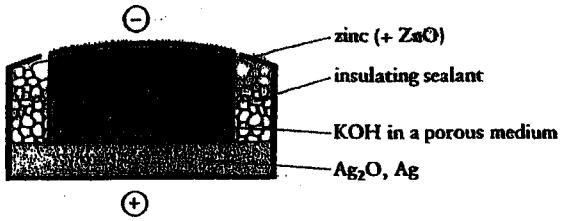
_____ **1**

Student No. _____

Marks

Question 20 [4 marks]

The diagram below represents a silver oxide button cell.



The overall cell reaction is expressed in the following word equation:

I. Zinc (solid) + silver oxide → zinc oxide + silver (solid)

The reduction half equation is expressed in the following word equation:

II. Silver oxide + water + $2e$ → silver (s) + hydroxide ions

(a) Write reaction I above as a balanced symbol equation.

_____

_____ **1**

(b) Identify the substance that is acting as the reductant and justify your choice.

_____

_____ **1**

(c) From the information given, deduce and write a balanced symbol equation for the oxidation half reaction.

_____ **1**

(d) State **ONE** advantage, apart from size, of this cell over the conventional dry cell.

_____

_____ **1**

Student No. _____

Question 21 [2 marks] **Marks**

Some isotopes such as ^{235}U undergo fission when bombarded by neutrons. Some isotopes, however, undergo nuclear reactions that produce new elements. These elements are called **transuranic elements**. Outline the way that transuranic elements are formed in a nuclear reaction and give **ONE** example of a transuranic element.

_____

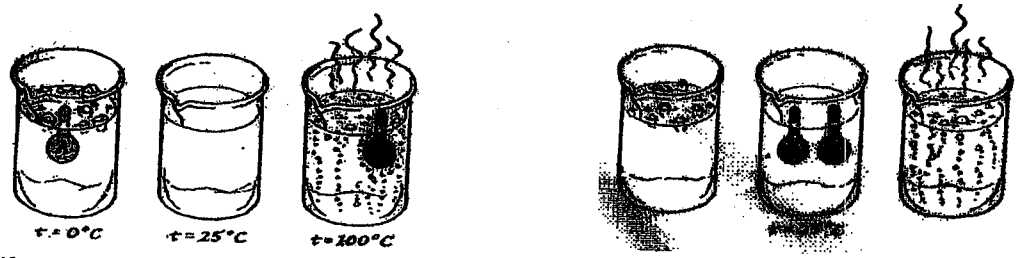
_____

_____

_____ 2

Question 22 (7 marks)

Two sealed tubes, containing identical equilibrium mixtures of dark brown NO_2 and colourless N_2O_4 are placed into beakers of hot water and iced water as shown in the diagram below. They are then moved to a beaker of water at room temperature. The observations made by students of the two tubes have been added to the labelled diagrams.



(a) An equation describing the equilibrium mixture is:

$$2\,NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$$

(dark brown) (colourless)

(i) In which direction (right or left as written) is the equilibrium reaction exothermic.

_____ 1

(ii) In terms of Le Chatelier's principal explain the students' observations.

_____

_____

_____

_____

_____ 2

Question 22 continued over page

Student No. _____

Question 22 (a) (Continued)

Marks

(iii) Given that Sydney's air is full of oxides of nitrogen and following on from the student's experimental observations, predict what you would expect to see as you look over the Sydney skyline on a still hot summer day.

Explain your prediction.

_____

_____

_____

_____ **1**

(b) Evidence shows that the overall **global** concentration of NO_2 in the atmosphere has not increased significantly over the last century.

Discuss the human activities that generate localised increases in NO_2 concentrations and the chemical processes which prevent localised increases from being dispersed globally.

Explain how these chemical processes pose a further threat to the environment.

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_____ **3**

Student No. _____

Marks

Question 23 (5 marks)

Esterification is an important industrial process for producing organic substances. Esterification can be carried out on a small scale in the school laboratory.

(a) Some students reacted methanol with butanoic acid. Name the ester they produced and using structural formulae write a chemical equation to describe this reaction.

Name of ester: _____

2

(b) Some specific conditions apply to the process of esterification, for example, refluxing and the addition of sulfuric acid.

Explain **ONE** reason for using reflux apparatus and **ONE** reason for adding sulfuric acid.

Reflux apparatus: _____

_____

Adding sulfuric acid: _____

_____ **2**

(c) Describe **ONE** characteristic of esters and how they are most commonly used.

_____

_____ **1**

Student No. _____

Marks

Question 24 (4 marks)

The reaction between hydrogen sulfide gas (H_2S) and water is an acid – base reaction according to Bronsted-Lowry theory.

(a) Write a balanced symbol equation for this reaction.

_____ **1**

(b) Define a Bronsted-Lowry acid.

_____

_____ **1**

(c) Identify the Bronsted-Lowry acid and its conjugate base in the above reaction.

B-L Acid: _____ Conjugate base: _____ **1**

(d) Explain, with the inclusion of electron dot diagrams, how the reaction can also be classified as a Lewis acid-base reaction.

_____

_____

_____ **1**

Student No. _____

Marks

Question 25 (7 marks)

To determine the concentration of acetic acid in a particular brand of vinegar, a student first diluted 25 mL of the vinegar accurately to 100 mL and then titrated 10 mL of the diluted solution with 0.097 M sodium hydroxide. The average titre was 17.2 mL.

(a) Calculate the concentration of the diluted solution and then the concentration of the original vinegar.

_____

_____

_____

_____

_____

_____ **2**

(b) Determine the mass of acetic acid in 100 mL of the original full strength vinegar.

_____

_____

_____

_____ **2**

(c) If the student mistakenly rinsed the burette with water before filling it with *NaOH*, what would be the effect on his calculated concentration of vinegar compared to its real concentration?

_____

_____ **1**

(d) Explain why the sodium hydroxide solution made from the molar mass of *NaOH* dissolved in 1 litre of water had to be standardised before using, in order for the titration to be accurate.

_____

_____

_____ **1**

(e) From the following table choose the most suitable indicator for determining the end-point in the titration of acetic acid and sodium hydroxide.

Indicator	pH range	Colour range (low pH–high pH)
Thymol blue	1.2 – 2.8	Red-yellow
Bromocresol green	3.8 – 5.4	Yellow-blue
Methyl red	4.4 – 6.2	Pink-yellow
Bromothymol blue	6.0 – 7.6	Yellow-blue
Thymol blue	8.0 – 9.6	Yellow-blue

_____ **1**

Student No. _____

Marks

Question 26 (6 marks)

Year 12 students were asked to plan and perform an experiment to assess the value of ethanol as a fuel.

(a) State **ONE** factor that would have to be included in a risk and hazard assessment for this experiment.

_____

_____

_____ 1

(b) They have decided to compare the heats of combustion of ethanol with three other easily obtainable alcohols and graph the results.

(i) Write a balanced symbol equation for the combustion of ethanol.

_____ 1

(ii) Draw a labelled diagram of the apparatus they would use to determine the heat of combustion and how it would be set up for such an experiment.

1

Question 26 continued over page

Student No. _____

Marks

(iii) Identify the measurements they would need to make.

_____

_____ **1**

(iv) When the data has been obtained, what formula could they apply to quantify the heat of combustion of each alcohol?

_____

_____ **1**

(v) When graphing this information, what labels would be put on the horizontal and vertical axes?

Vertical axis: _____

Horizontal axis: _____ **1**

Student No. _____

Section III – Option
Total marks (25)
Allow about 45 minutes for this section
Attempt ALL questions

Use the spaces provided on the paper

Question 27 – Shipwrecks and Salvage (25 marks) **Marks**

(a) The hulls of ships are made of steel alloys which corrode rapidly to form rust. Aluminium, however, is quite resistant to corrosion.

(i) Compare the standard reduction potentials of iron and aluminium and justify from these values which metal should corrode more readily.

_____

_____

_____ **2**

(ii) Assess your answer to (i) in the light of the opening statement and explain any anomalies.

_____

_____

_____ **1**

(iii) Define the term *passivating metal* and give **ONE** example of a passivating metal.

_____

_____ **1**

(iv) Describe how rust forms on the hull of a ship giving the necessary chemical equations for each step of the process. Identify the product that is called rust.

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_____ **5**

Question 27 continued over page

Student No. _____

Marks

(v) Steel ships are often protected from rusting by bolting blocks of magnesium to their hulls. Explain how this prevents rusting, and name the process involved.

_____

_____

_____

_____

_____

_____ **2**

(vi) State **ONE** reason that large ocean going vessels are not built of aluminium even though it does not rust.

_____

_____

_____ **1**

(b) (i) Year 12 performed, either in class or at home, some open-ended investigations to determine the rate of iron corrosion when temperature, electrolyte concentration, oxygen concentration or pH was varied. Assess the impact of **ONE** of these on the corrosion rate of iron.

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_____ **3**

Question 27 continued over page

Student No. _____

Question 27 (b) (Continued) **Marks**

(ii) Scientists were immensely surprised when the Titanic was discovered, to find such a large extent of rusting. They had expected, due to the variables mentioned in (i) to find it reasonably uncorroded. Outline the biological mechanisms that have largely contributed to its corrosion.

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_____ **3**

(c) Outline the contribution of Galvani to understanding the process of electron transfer.

_____

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_____ **2**

(d) A concentrated aqueous solution of copper nitrate was electrolysed using inert electrodes.

(i) Write half equations for the reactions that occurred at the electrodes.

Anode: _____ **1**

Cathode: _____ **1**

Question 27 continued over page

Student No. _____

Question 27 (d) (Continued) **Marks**

(ii) Describe the electrode processes if the electrolysis in (i) was repeated using copper electrodes.

Anode: _____

_____

_____

Cathode: _____

_____

_____

_____ **2**

(iii) Discuss **ONE** factor that would affect the rate of the electrolysis reactions in (i) and (ii) above.

_____

_____

_____ **1**

END OF PAPER

CHEMISTRY DATA SHEET

Values of several numerical constants

Avogadro's constant, N_A	6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas:	
at 101.3 kPa (1.00 atm) and	
at 273 K (0°C)	22.41 L
at 298 K (25°C)	24.47 L
Ionisation constant for water	
at 298 K (25°C), K_w	1.0×10^{-14}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

Some useful formulae

$\mathrm{pH} = -\log_{10}[\mathrm{H^+}]$ $\qquad$ $\Delta H = m\,C\,\Delta T$

Some standard potentials

Some standard potentials at 298 K (25°C)

Oxidant		Reductant	$E^\ominus$
$K^+ + e^-$	$\rightleftharpoons$	$K(s)$	−2.92 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba(s)$	−2.90 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca(s)$	−2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na(s)$	−2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg(s)$	−2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al(s)$	−1.66 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn(s)$	−1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g) + OH^-$	−0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn(s)$	−0.76 V
$S(s) + 2e^-$	$\rightleftharpoons$	S^{2-}	−0.48 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe(s)$	−0.41 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni(s)$	−0.23 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn(s)$	−0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb(s)$	−0.13 V
$CO_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$HCHO + H_2O$	−0.07 V
$CO_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$\frac{1}{6} C_6H_{12}O_6$(glucose) $+ H_2O$	−0.01 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_2(g)$	0.00 V
$CO_2(g) + 6H^+ + 6e^-$	$\rightleftharpoons$	$CH_3OH + H_2O$	0.03 V
$Sn^{4+} + 2e^-$	$\rightleftharpoons$	Sn^{2+}	0.15 V
$CO_2(g) + 8H^+ + 8e^-$	$\rightleftharpoons$	$CH_4(g) + 2H_2O$	0.17 V
$HCHO + 2H^+ + 2e^-$	$\rightleftharpoons$	CH_3OH	0.24 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu(s)$	0.35 V
$O_2(g) + 2H_2O + 4e^-$	$\rightleftharpoons$	$4OH^-$	0.40 V
$HCHO + 4H^+ + 4e^-$	$\rightleftharpoons$	$CH_4(g) + H_2O$	0.41 V
$NiO_2(s) + 2H_2O + 2e^-$	$\rightleftharpoons$	$Ni(OH)_2(s) + 2OH^-$	0.49 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu(s)$	0.52 V
$I_2(s) + 2e^-$	$\rightleftharpoons$	$2I^-$	0.54 V
$I_2(aq) + 2e^-$	$\rightleftharpoons$	$2I^-$	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag(s)$	0.80 V
$Br_2(l) + 2e^-$	$\rightleftharpoons$	$2Br^-$	1.07 V
$Br_2(aq) + 2e^-$	$\rightleftharpoons$	$2Br^-$	1.09 V
$O_2(g) + 4H^+ + 4e^-$	$\rightleftharpoons$	$2H_2O$	1.23 V
$Cr_2O_7^{2-} + 14H^+ + 6e^-$	$\rightleftharpoons$	$2Cr^{3+} + 7H_2O$	1.33 V
$Cl_2(g) + 2e^-$	$\rightleftharpoons$	$2Cl^-$	1.36 V
$Cl_2(aq) + 2e^-$	$\rightleftharpoons$	$2Cl^-$	1.40 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	Symbol of element	Name of element
79	Au	Gold
Atomic Weight	197.0	

1 H .008 ydrogen																	2 He 4.003 Helium
3 Li .941 ithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 2.99 idium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K).10 assium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb .47 idium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 2.9 ium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr 3.0] ium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets. The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

This sheet should be REMOVED for your convenience.