

Student No. _____



Barker College

**2001
TRIAL
HIGHER SCHOOL
CERTIFICATE**

Chemistry

Staff Involved:

- KHW*
- KJB
- ASM
- JRH

PM FRIDAY 10 AUGUST

72 copies

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.

(A) ☒ (B) ☒ (C) ☐ (D) ☐

correct →

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.



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

- (A) As pressure decreases the equilibrium between $\text{CO}_{2(aq)}$ and $\text{CO}_{2(g)}$ shifts towards $\text{CO}_{2(g)}$.
- (B) The pressure increases and the equilibrium moves to make more CO_2 in the solution.
- (C) The reaction moves to the right increasing $[\text{H}_2\text{CO}_3]$, reducing $[\text{CO}_2]$ and making the soda water flat.
- (D) As the concentration of H_2CO_3 decreases more CO_2 dissolves making the soda water flat.

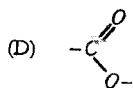
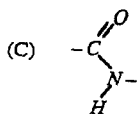
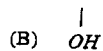
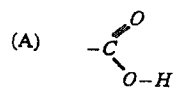
9. Which of the following is the conjugate base of H_2PO_4^- ?

- (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 pH. Which of the following substances would need to be added to 100 mL of 0.2 M ethanoic acid to 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 molecule with the H^+ ion?
- (A) Hydrogen bond
(B) Ionic bond
(C) Covalent bond
(D) Metallic bond
13. Ammonium chloride (NH_4Cl) is a white water soluble solid. The pH of 1 mol L^{-1} solution of 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 alkanolic acid functional group?



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.

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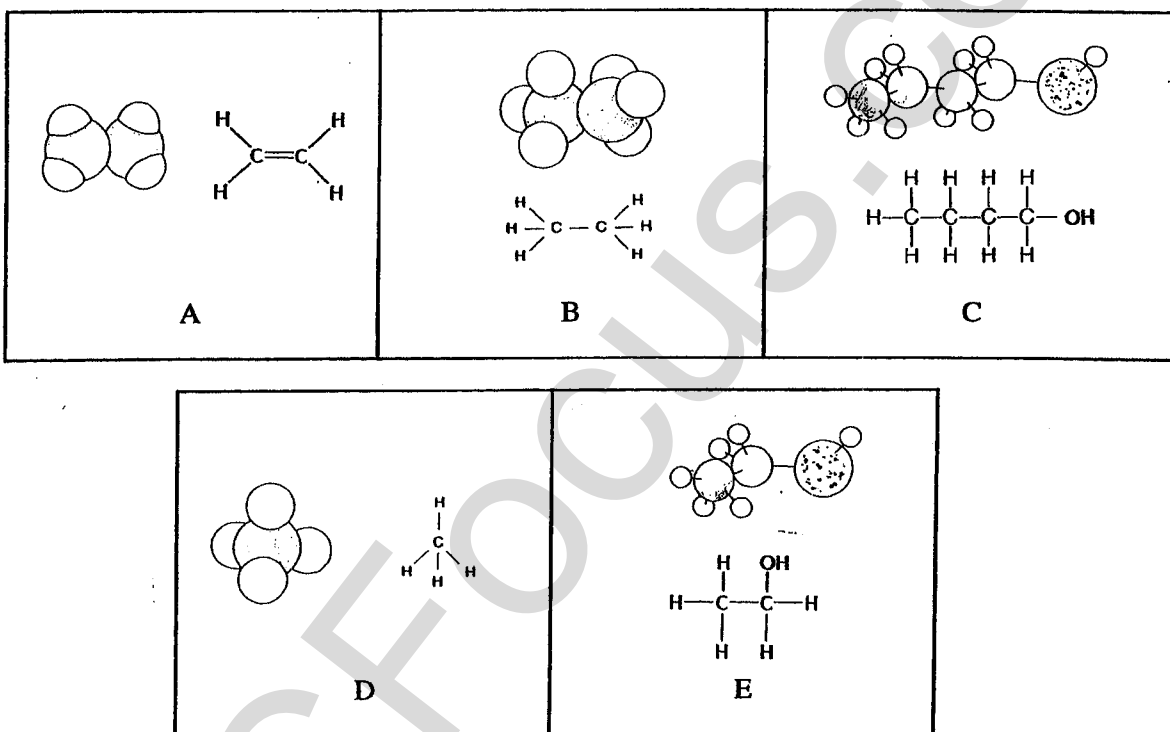
Section II
Total marks (60)
Attempt ALL questions
Allow about 110 minutes for this section

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

Question 16 (Continued)

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

Question 17 [5 marks]

Chlorine is used for the manufacture of C_2H_3Cl , a monomer that undergoes **addition** polymerisation.

- (a) Draw the full structural formula for C_2H_3Cl

1

- (b) Give the systematic name for the monomer C_2H_3Cl .

1

- (c) Draw the structural formula of the polymer that is produced from C_2H_3Cl 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.

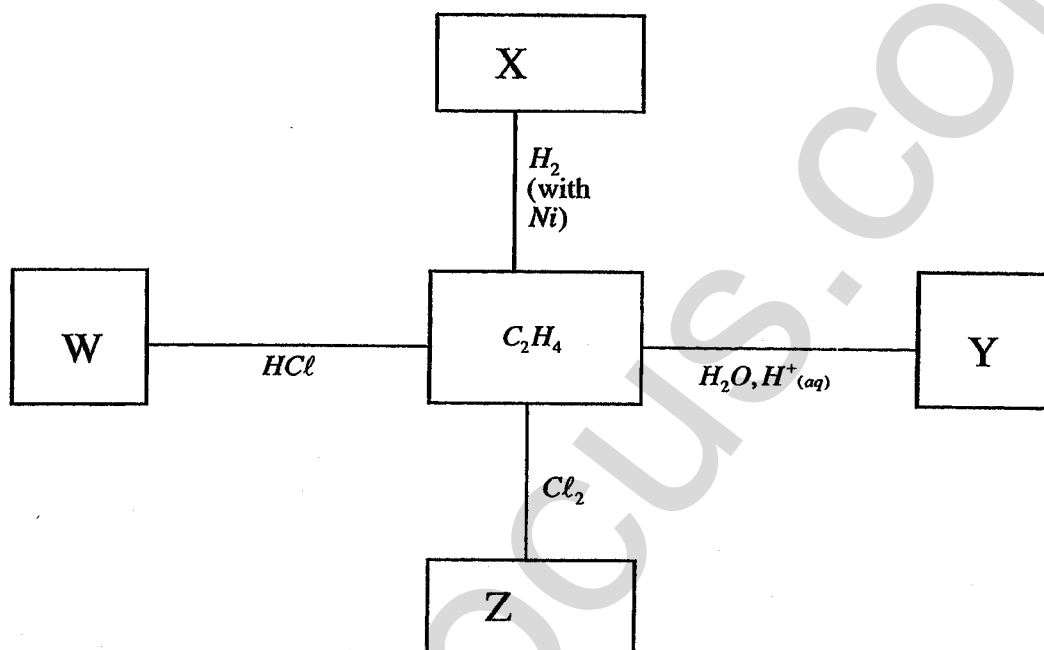
2

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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

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.

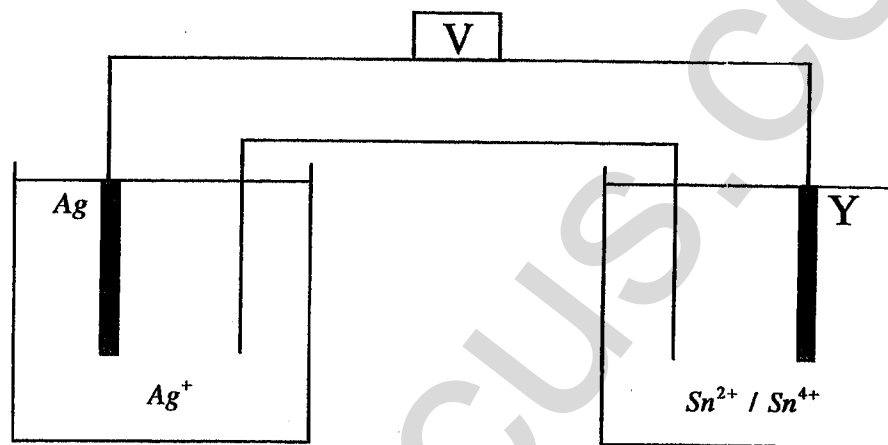
2

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 $\text{Ag}^+_{(\text{aq})} / \text{Ag}_{(\text{s})}$ and $\text{Sn}^{4+}_{(\text{aq})} / \text{Sn}^{2+}_{(\text{aq})}$, as in the diagram below.



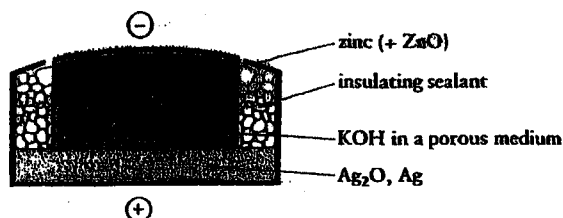
- (a) Using arrows and labels clearly indicate the direction of electron flow and migration of ions. 1
- (b) Write the equation for the reaction that occurs at the anode. 1
- _____
- (c) Describe **TWO** factors that would have to be considered when selecting an appropriate chemical for the salt bridge. 1
- _____
- (d) Showing all steps in your working calculate the maximum EMF that this experimental cell could produce. 1
- _____
- _____
- _____

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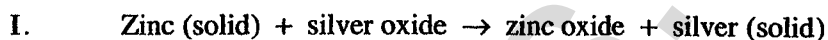
Question 20 [4 marks]

Marks

The diagram below represents a silver oxide button cell.



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



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



(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

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Question 21 [2 marks]

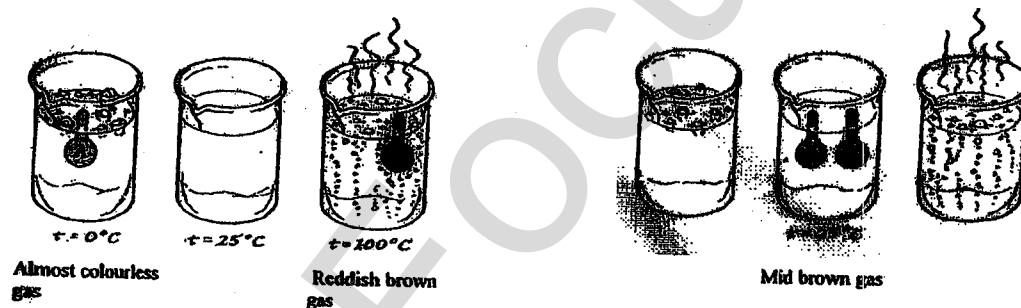
Marks

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.

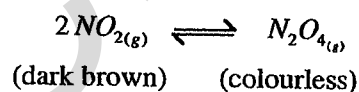
2

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:



- (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

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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.

Blank lined paper with a large diagonal watermark reading "TSCF".

3

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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

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

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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

Question 26 (Continued)

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

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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.

5

Question 27 continued over page

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.

SCF

3

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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.

3

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

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	$6.022 \times 10^{23} \text{ mol}^{-1}$
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	$4.18 \times 10^3 \text{ J kg}^{-1} \text{ K}^{-1}$

Some useful formulae

$$\text{pH} = -\log_{10} [\text{H}^+]$$

$$\Delta H = m C \Delta T$$

Some standard potentials

Some standard potentials at 298 K (25°C)

Oxidant	Reductant	E°
$\text{K}^+ + \text{e}^-$	K(s)	-2.92 V
$\text{Ba}^{2+} + 2\text{e}^-$	Ba(s)	-2.90 V
$\text{Ca}^{2+} + 2\text{e}^-$	Ca(s)	-2.87 V
$\text{Na}^+ + \text{e}^-$	Na(s)	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	Mg(s)	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	Al(s)	-1.66 V
$\text{Mn}^{2+} + 2\text{e}^-$	Mn(s)	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	$\frac{1}{2} \text{H}_2(\text{g}) + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	Zn(s)	-0.76 V
$\text{S(s)} + 2\text{e}^-$	S^{2-}	-0.48 V
$\text{Fe}^{3+} + 2\text{e}^-$	Fe(s)	-0.41 V
$\text{Ni}^{2+} + 2\text{e}^-$	Ni(s)	-0.23 V
$\text{Sn}^{2+} + 2\text{e}^-$	Sn(s)	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	Pb(s)	-0.13 V
$\text{CO}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$	$\text{HCHO} + \text{H}_2\text{O}$	-0.07 V
$\text{CO}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$	$\frac{1}{6} \text{C}_6\text{H}_{12}\text{O}_6(\text{glucose}) + \text{H}_2\text{O}$	-0.01 V
$\text{H}^+ + \text{e}^-$	$\frac{1}{2} \text{H}_2(\text{g})$	0.00 V
$\text{CO}_2(\text{g}) + 6\text{H}^+ + 6\text{e}^-$	$\text{CH}_3\text{OH} + \text{H}_2\text{O}$	0.03 V
$\text{Sn}^{4+} + 2\text{e}^-$	Sn^{2+}	0.15 V
$\text{CO}_2(\text{g}) + 8\text{H}^+ + 8\text{e}^-$	$\text{CH}_4(\text{g}) + 2\text{H}_2\text{O}$	0.17 V
$\text{HCHO} + 2\text{H}^+ + 2\text{e}^-$	CH_3OH	0.24 V
$\text{Cu}^+ + 2\text{e}^-$	Cu(s)	0.35 V
$\text{O}_2(\text{g}) + 2\text{H}_2\text{O} + 4\text{e}^-$	4OH^-	0.40 V
$\text{HCHO} + 4\text{H}^+ + 4\text{e}^-$	$\text{CH}_4(\text{g}) + \text{H}_2\text{O}$	0.41 V
$\text{NiO}_2(\text{s}) + 2\text{H}_2\text{O} + 2\text{e}^-$	$\text{Ni(OH)}_2(\text{s}) + 2\text{OH}^-$	0.49 V
$\text{Cu}^+ + \text{e}^-$	Cu(s)	0.52 V
$\text{I}_2(\text{s}) + 2\text{e}^-$	2I^-	0.54 V
$\text{I}_2(\text{aq}) + 2\text{e}^-$	2I^-	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	Fe^{2+}	0.77 V
$\text{Ag}^+ + \text{e}^-$	Ag(s)	0.80 V
$\text{Br}_2(\text{l}) + 2\text{e}^-$	2Br^-	1.07 V
$\text{Br}_2(\text{aq}) + 2\text{e}^-$	2Br^-	1.09 V
$\text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$	$2\text{H}_2\text{O}$	1.23 V
$\text{Cr}_2\text{O}_7^{2-} + 14\text{H}^+ + 6\text{e}^-$	$2\text{Cr}^{3+} + 7\text{H}_2\text{O}$	1.33 V
$\text{Cl}_2(\text{g}) + 2\text{e}^-$	2Cl^-	1.36 V
$\text{Cl}_2(\text{aq}) + 2\text{e}^-$	2Cl^-	1.40 V

PERIODIC TABLE OF THE ELEMENTS

KEY

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

1 H .008	2 He 4.003	3 Li .941	4 Be 9.012	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.08
21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39
39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc [98.91]	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4
57-71 Lanthanides	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 195.1	79 Au 197.0	80 Hg 200.6
89-103 Actinides	104 Rf [261.1]	105 Db [262.1]	106 Sg [263.1]	107 Bh [264.1]	108 Hs [265.1]	109 Mt [268]	110 Uun —	111 Uuu —	112 Uub —
	121 Nh [289.1]	122 Db [288.1]	123 Ts [284.1]	124 Og [284.1]	125 Lr [260.1]	126 Uut [289.1]	127 Uuq [288.1]	128 Uub [286.1]	129 Uut [286.1]

Lanthanides

57 La 138.9	58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm [146.9]	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	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
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Actinides

89 Ac [227.0]	90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np [237.0]	94 Pu [239.1]	95 Am [241.1]	96 Cm [244.1]	97 Bk [249.1]	98 Cf [252.1]	99 Es [252.1]	100 Fm [257.1]	101 Md [258.1]	102 No [259.1]	103 Lr [262.1]
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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 ²³⁷Np and ⁹⁹Tc.

This sheet should be REMOVED for your convenience.