SYDNEY GRAMMAR SCHOOL

2006
FORM VI
TRIAL HSC EXAMINATION

Chemistry

General Instructions

- Reading time – 5 minutes.
- Working time – 3 hours
- Board-approved calculators may be used
- Write using blue or black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- Write your candidate number and class at the top of each page in Part B and on the answer booklet

CHECKLIST	
Each boy should have the following :	
1 Question Paper	
1 Multiple Choice Answer Sheet	
1 8 - Page Booklet	

Chemistry Classes.

1 JAG	2 JME	3 AKBB
4 MMB	5 AKBB	6 JAG

Section I Pages 2 - 24

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**
- Attempt Questions 1-15
- Allow about 25 minutes for this Section

Part B
Total marks **(69)**
- Attempt Questions 16-29
- Allow about 2 hours for this Section

Section II Pages 25-28
Total marks **(16)**
- Attempt Question 30 in this section.
- Allow about 35 minutes for this Section

Part A

Total marks (15)
Attempt Questions 1-15
Allow about 25 minutes for this Part

Use the multiple-choice Answer Sheet.

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

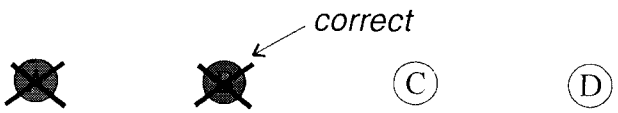
Sample 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

Ⓐ ● Ⓒ Ⓓ

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

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.



1 What is a free radical?

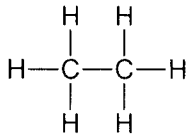
(A) An atom or molecule with an unpaired electron.
(B) A particle that is free to move in a chemical reaction.
(C) A charged particle that is free to move.
(D) An organo-halogen compound.

2 Which of the following is the catalyst used in the Haber process?

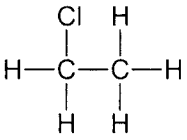
(A) iron-iron oxide
(B) zeolite
(C) conc H_2SO_4
(D) V_2O_5

3 Which of the following substances could not be produced by ethene undergoing an addition reaction?

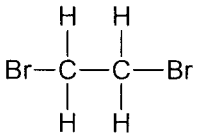
(A)



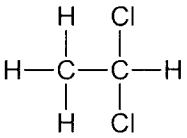
(B)



(C)



(D)



4 Which of the following statements best describes condensation polymerisation?

(A) The reaction between many units, whereby the units link to each other across their double bonds to form a chain.
(B) The reaction between many units, whereby the functional groups of the units react in such a way as to form a chain and expel water molecules.
(C) The reaction between many units, whereby the amine group of one molecule reacts with the carboxyl group of the next to form a chain and expel water.
(D) The reaction between many units, whereby the units link to each other to form a chain and to expel many small molecules.

5 Which of the following represents the ideal conditions for fermentation to occur?

(A) Air is excluded; zymase(yeast) is added; $\approx 35^{o}C$.
(B) Conc. H_2SO_4 is added; zymase(yeast) is present; $\approx 35^{o}C$.
(C) Mixture is oxygenated; zymase(yeast) is added; $\approx 25^{o}C$.
(D) Low O_2 environment; zymase(yeast) is added; mixture is refluxed.

6 The first four steps in the decay series for Uranium 238 can be represented as follows:

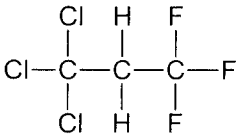
$$^{238}_{92}U \xrightarrow[\text{Step 1}]{} {}^{234}_{90}Th \xrightarrow[\text{Step 2}]{} {}^{234}_{91}Pa \xrightarrow[\text{Step 3}]{} {}^{234}_{92}U \xrightarrow[\text{Step 4}]{} {}^{230}_{90}Th$$

The types of radiation which accompany each of steps 1 to 4, are respectively-

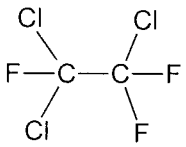
(A) $\beta, \alpha, \alpha, \beta$
(B) $\alpha, \beta, \gamma, \delta$
(C) $\alpha, \beta, \beta, \alpha$
(D) $\beta, \gamma, \gamma, \beta$

7 Which of the compounds below are isomers?

(I)



(II)



(III) 1,1,1-trichloro-2,2,2-trifluoroethane

(IV) 3,3,3-trichloro-1,1,1-trifluoropropane

(A) (I) and (IV)
(B) (II) and (III)
(C) (I) and (II)
(D) (III) and (IV)

8 A lawn food containing 56.6% ammonium sulfate (FW = 132) was analysed by precipitating the sulfate as barium sulfate (FW = 233). What is the mass of dry barium sulfate expected from 1.00g of the lawn food?

(A) 0.566g
(B) 1.00g
(C) 1.77g
(D) 2.00g

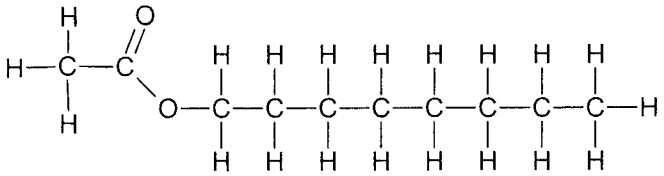
9 What is the change in pH when 10mL of 0.1M $HCl_{(aq)}$ is diluted with 990mL of deionised water?

(A) increase by 2
(B) decrease by 2
(C) increase by 3
(D) decrease by 3

10 How is a Bronsted-Lowry acid best described?

(A) A substance which forms H^+ ions in water
(B) A substance which contains oxygen
(C) A substance which is a proton donor
(D) A substance which contains hydrogen

11 What is the name of the ester below?



(A) ethyl octanoate
(B) octyl ethanoate
(C) methyl octanoate
(D) heptyl ethanoate

12 Which of the salts below produces a basic solution when dissolved in water?

(A) NH_4Cl
(B) KNO_3
(C) KCH_3CH_2COO
(D) $FeCl_3$

13 A galvanic cell is set up using magnesium and copper half-cells. The equation for the reaction in the cell is:

$$Mg_{(s)} + Cu^{2+}_{(aq)} \rightarrow Mg^{2+}_{(aq)} + Cu_{(s)}$$

Which of the following statements applies when the galvanic cell is producing electricity?

(A) The mass of the copper electrode decreases.
(B) Electrons flow from the copper half-cell to the magnesium half-cell.
(C) Electrons are lost from magnesium atoms.
(D) Anions flow through the salt bridge from the magnesium half-cell to the copper half-cell.

14 Which of the following solutions contains the greatest number of moles of solute?

(A) 10.0mL of 0.50M $HCl_{(aq)}$
(B) 20.0mL of 0.40M $HCl_{(aq)}$
(C) 30.0mL of 0.30M $HCl_{(aq)}$
(D) 40.0mL of 0.20M $HCl_{(aq)}$

15 Which of the following statements best describes how a catalyst operates in a reversible reaction?

(A) The catalyst increases the enthalpy change of the reverse reaction.
(B) The catalyst decreases the enthalpy change of the forward reaction.
(C) The catalyst decreases the activation energy of both the forward and backward reactions.
(D) The catalyst increases the activation energy of the reverse reaction.

Class Candidate Number

Part B

Total marks (69)
Attempt ALL Questions
Allow about 2 hours for this Part

Answer the questions in the spaces provided
Show **all** relevant working in questions involving calculations

Marks

Question 16 (6 marks)

At the start of the HSC course you performed an experiment that allowed you to distinguish between alkanes and alkenes.

(a) Identify an alkane and an alkene which you used in this experiment plus any other reagents used. **2**

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(b) Identify the hazards involved in this experiment. **2**

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(c) Write an equation for any reaction which occurred. **2**

Class

Candidate Number

Question 17 (3 marks)

Distinguish between stable and radioactive isotopes and identify the conditions under which a nucleus is unstable. **3**

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Question 18 (2 marks)

Complete the following table, which refers to a number of titrations carried out in a school laboratory using solutions in the range 0.1-0.5M. **2**

Titrant	Other reactant	Appropriate indicator
HCl	NaOH	
CH_3COOH	LiOH	
NH_3	HNO_3	

Class Candidate Number

Marks

Question 19 (4 marks)

(a) Draw a labelled diagram of an operating galvanic cell that is made up of two half cells, each containing a metal in contact with its ions. Label the cathode, the anode, and the salt bridge. **3**

(b) Calculate the voltage of this cell under standard conditions. **1**

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Class

Candidate Number

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Class Candidate Number

Marks

Question 20 (3 marks)

Explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium. **3**

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Question 21 (3 marks)

Compare one physical and one chemical property of the oxygen allotropes O_2 and O_3 and account for the differences on the basis of structure and bonding. **3**

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Class

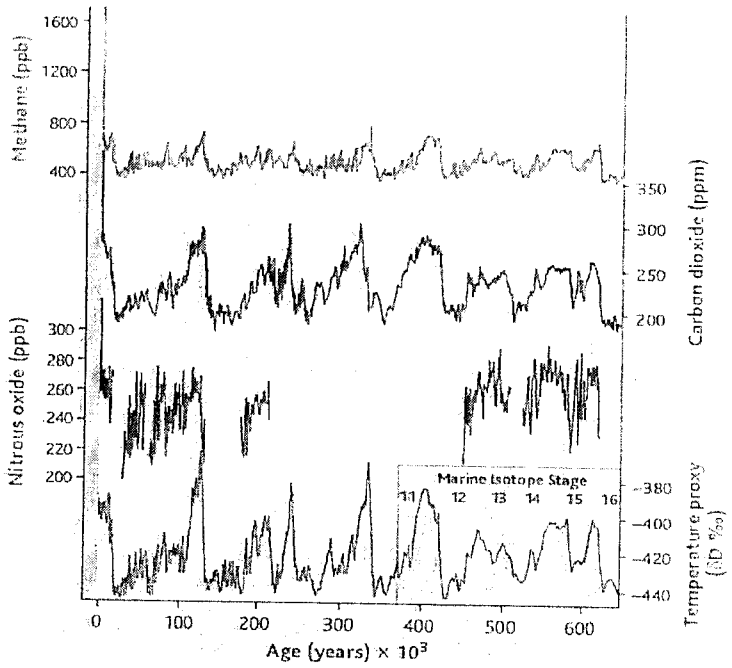
Candidate Number

Marks

Question 22 (4 marks)

Consider the data on the greenhouse gases presented in the graph below.

The greenhouse gas and deuterium (δD) records for the past 650,000 years from ice cores. δD, the deviation of the deuterium/hydrogen ratio from an isotope standard, is a proxy for air temperature; more positive values indicate warmer conditions.



(a) Which gas was most abundant in the atmosphere 500 000 years ago? **1**

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(b) Write chemical formulas for the three gases. **1**

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(c) Assess the validity of the claim that these three gases are greenhouse gases. **2**

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Class Candidate Number

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Question 23 (4 marks)

Discuss the use of neutralisation in dealing with an acid spill in a laboratory. **4**

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Class

Candidate Number

Marks

Question 24 (4 marks)

One acidic oxide found in the atmosphere is $SO_{2(g)}$.

(a) Name one natural and one industrial source of $SO_{2(g)}$. **1**

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(b) Write an equation to demonstrate the acidic nature of $SO_{2(g)}$. **1**

(c) At 25°C and 100kPa, what volume of $SO_{2(g)}$ would be needed to produce 500mL of 1.05M sulfurous acid? **2**

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Class Candidate Number

Marks

Question 25 (5 marks)

In an experiment to determine the ammonia concentration in a bottle of cloudy ammonia, a student transferred a 25.00mL aliquot of cloudy ammonia to a 250.0mL volumetric flask and made it up to 250.0 mL with deionised water. The contents of this volumetric flask were thoroughly mixed. The student then titrated 25.00mL aliquots of this solution against 0.2530M HCl and obtained an average titre volume of 22.50mL. Assume the density of the ammonia solution is 0.950 g/mL.

Calculate the concentration of NH_3 in the cloudy ammonia as %w/w (grams per 100g of solution). **5**

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Class

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Class Candidate Number

Marks

Question 26 (7 marks)

Chemical monitoring of the concentrations of ions such as Mg^{2+}, Ca^{2+}, NO_3^-, PO_4^{3-} is important to manage the quality of water resources.

For <u>one</u> cation and <u>one</u> anion from the list above:

(a) Identify a possible source and state whether the source is natural or a result of human activity. **2**

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(b) Explain why monitoring and management of the concentrations of the <u>two</u> ions you have chosen is important. **2**

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(c) Discuss the range and chemistry of tests used to monitor <u>one</u> of the ions you have chosen. **3**

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Class Candidate Number

Marks

Question 27 (8 marks)

Human activity has caused changes in the composition and structure of the atmosphere.

(a) Identify the origins of CFCs and halons in the atmosphere. **1**

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(b) Explain the impacts of CFCs and halons on the atmosphere. **4**

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Question 27 continued on next page.

Class Candidate Number

Question 27 continued

Marks

(c) Assess the measures being taken to alleviate the problems associated with CFCs. **3**

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Class

Candidate Number

Marks

Question 28 (8 marks)

(a) Draw the structural formulas of 1-hexanol and propanoic acid. Circle and name the functional groups in these molecules. **2**

(b) 1-hexanol and 3,3-dimethyl-1-butanol are isomers. Explain why 1-hexanol has a higher boiling point than 3,3-dimethyl-1-butanol. **2**

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(c) Draw a fully labelled diagram of the apparatus needed to esterify 1-hexanol and propanoic acid in a school laboratory. **2**

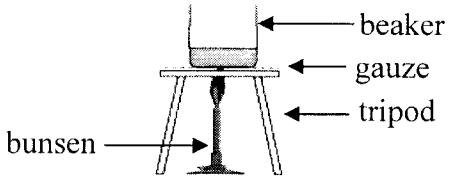
Question 26 continued on next page.

Class Candidate Number

Question 26 continued

Marks

(d) Explain why the apparatus you drew in (c) would be more appropriate than the apparatus below. **2**



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Class

Candidate Number

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Class

Candidate Number

Marks

Question 29 (8 marks)

It has been said that in the 21st century wars will be fought for access to natural resources such as oil and water, and some people feel that this has already begun. **8**

Discuss the need for alternative sources of the compounds presently obtained from petrochemicals and evaluate the effect that using these alternative sources will have on environmental concerns such as global warming.

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Class

Candidate Number

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Section II

Class Candidate Number

16 marks
Attempt question 30 in this section.
Allow about 35 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

		Pages
Question 30	**Industrial Chemistry**	**27**
Question 31	**Elective 2**	
Question 32	**Elective 3**	
Question 33	**Elective 4**	
Question 34	**Elective 5**	

Class

Candidate Number

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Class Candidate Number

Marks

Question 30 (16 marks)

(a) Most sulfuric acid is manufactured on the industrial scale using the Contact process which involves the conversion of sulfur dioxide gas into sulfur trioxide gas.

(i) Write a chemical equation for this reaction and an expression for the equilibrium constant, K. **1**

(ii) How does an increase in pressure affect the value of the equilibrium constant? **1**

(b) Nitrogen dioxide is a poisonous brown gas which may be involved in the production of photochemical smog. **4**

In an experiment 5.0 mol of dinitrogen tetraoxide were added to a 20L vessel and the system reached equilibrium. At equilibrium 3.8 mol of dinitrogen tetraoxide remained. Calculate the equilibrium constant, K, for this reaction:

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

(c) (i) Describe one reaction in which concentrated sulfuric acid is acting as an oxidant. Include a relevant chemical equation. **2**

(ii) Describe one reaction in which concentrated sulfuric acid is acting as a dehydrating agent. Include a relevant chemical equation. **2**

(d) During your practical work you have performed a first-hand investigation to analyse the effect of disturbing an equilibrium reaction.

(i) Outline the procedure you used in this investigation. **3**

(ii) Explain how you analysed the equilibrium reaction in a qualitative way. **3**

Class Candidate Number

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Chemistry

Data Sheet

Avogadro's constant, N_A		6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas:	at 100 kPa and	
	at 0 °C (273 K)	22.71L
	at 25 °C (298K)	24.79 L
Ionisation constant for water at 25°C (298.15 K), K_w		1.0×10^{-14}
Specific heat capacity of water		4.18×10^3 Jkg^{-1}K^{-1}

Some useful formulae

$pH = -\log_{10}[H^+]$ $\Delta H = -mC\Delta T$

Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K_{(s)}$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba_{(s)}$	–2.91 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
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al_{(s)}$	–1.68 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
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe_{(s)}$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni_{(s)}$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn_{(s)}$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb_{(s)}$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_{2(g)}$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_{2(g)} + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.34 V
$\frac{1}{2} O_{2(g)} + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.52 V
$\frac{1}{2} I_{2(s)} + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2} I_{2(aq)} + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag_{(s)}$	0.80 V
$\frac{1}{2} Br_{2(l)} + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2} Br_{2(aq)} + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2} O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_{2(g)} + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2} Cl_{2(aq)} + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2} F_{2(g)} + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number 79 — Symbol of element: Au

Atomic Weight 197.0 — Name of element: Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	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 22.99 Sodium	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 39.10 Potassium	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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	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 [97.91] 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 132.9 Caesium	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 [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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.

SYDNEY GRAMMAR SCHOOL

2006
FORM VI
TRIAL HSC EXAMINATION

Chemistry Marking scheme and CRIB

General Instructions

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4 MMB	5 AKBB	6 JAG

Section I Pages 2 - 24

Total marks (100)

This section has two parts, Part A and Part B

Part A
Total marks **(15)**
- Attempt Questions 1-15
- Allow about 25 minutes for this Section

Part B
Total marks **(69)**
- Attempt Questions 16-29
- Allow about 2 hours for this Section

Section II Pages 25-28
Total marks **(16)**
- Attempt Question 30 in this section.
- Allow about 35 minutes for this Section

Part A
Total marks (15)
Attempt Questions 1-15
Allow about 25 minutes for this Part

1. A
2. A
3. D
4. D
5. A
6. C
7. B
8. B
9. A
10. C
11. B
12. C
13. C
14. C
15. C

Class Candidate Number

Part B
Total marks (69)
Attempt ALL Questions
Allow about 2 hours for this Part

Answer the questions in the spaces provided
Show **all** relevant working in questions involving calculations

Marks

Question 16 (6 marks)

At the start of the HSC course you performed an experiment that allowed you to distinguish between alkanes and alkenes.

(a) Identify an alkane and an alkene which you used in this experiment plus any other reagents used. **2**

Name a specific alkane and alkene (1 mark)

which could have been used by them and bromine water (1 mark)

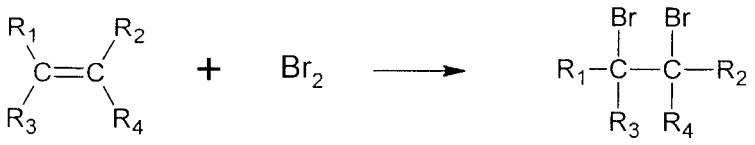
(b) Identify the hazards involved in this experiment. **2**

Organics – flammable and toxic

Br_2 – corrosive and toxic

(c) Write an equation for any reaction which occurred. **2**

Any completely correct equation (2 marks)
minus 1 mark for every mistake
e.g.



If alkane substitution reaction is used U.V. must be included in equation

Class Candidate Number

Question 17 (3 marks)

Distinguish between stable and radioactive isotopes and identify the conditions under which a nucleus is unstable. **3**

Definition of radioisotope (not using terms unstable or emit radiation) (1 mark)

Must be correct i.e. non-linear progression. Large nuclei (if specific size given, must be correct) (1 mark)

e.g. For elements with a small atomic mass there is a stable ratio of protons:neutrons known as the zone of stability. Isotopes whose proton:neutron ratio lies outside this zone are unstable and will decay/disintegrate/break-up. In addition if nuclei are very large (atomic no.>83) they are unstable and will decay.

Question 18 (2 marks)

Complete the following table, which refers to a number of titrations carried out in a school laboratory using solutions in the range 0.1-0.5M. **2**

Titrant	Other reactant	Appropriate indicator
HCl	NaOH	*Bromothymol blue Methyl orange Phenolphthalein*
CH_3COOH	LiOH	*Phenolphthalein*
NH_3	HNO_3	*Methyl orange*

all correct (2 marks)
one mistake (1 mark)

Class Candidate Number

Marks

Question 19 (4 marks)

(a) Draw a labelled diagram of an operating galvanic cell that is made up of two half cells, each containing a metal in contact with its ions. Label the cathode, the anode, and the salt bridge. **3**

Diagram (1 mark)

Metal + metal ions, salt bridge (1mark)

Identified cathode and anode, named electrolyte in salt bridge (1 mark)

(b) Calculate the voltage of this cell under standard conditions. **1**

Values are given to 2 decimal places ∴ so should answers be. Calculate means show working.

Mg/Mg2+//Zn2+/Zn = 1.60V

Mg/Mg2+// /Cu^{2+}/Cu = 2.70V

Mg/Mg^{2+}//Ag^{+}/Ag = 3.16V

etc

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Class Candidate Number

Marks

Question 20 (3 marks)

Explain why the Haber process is based on a delicate balancing act involving reaction energy, reaction rate and equilibrium. **3**

State Haber process exothermic. If T ↑ rate ↑ but yield ↓ (1 mark)

Explain rate needs to be reasonably high so process economically viable (1 mark)

'Compromise' temperature chosen and explanation (both rate and yield considered) (1 mark)

Question 21 (3 marks)

Compare one physical and one chemical property of the oxygen allotropes O_2 and O_3 and account for the differences on the basis of structure and bonding. **3**

Describe structure (shape) and bonding (polar) in both O_2 and O_3 (1 mark)

Compare 1 physical and 1 chemical property of O_2 and O_3 (2 marks)

Class

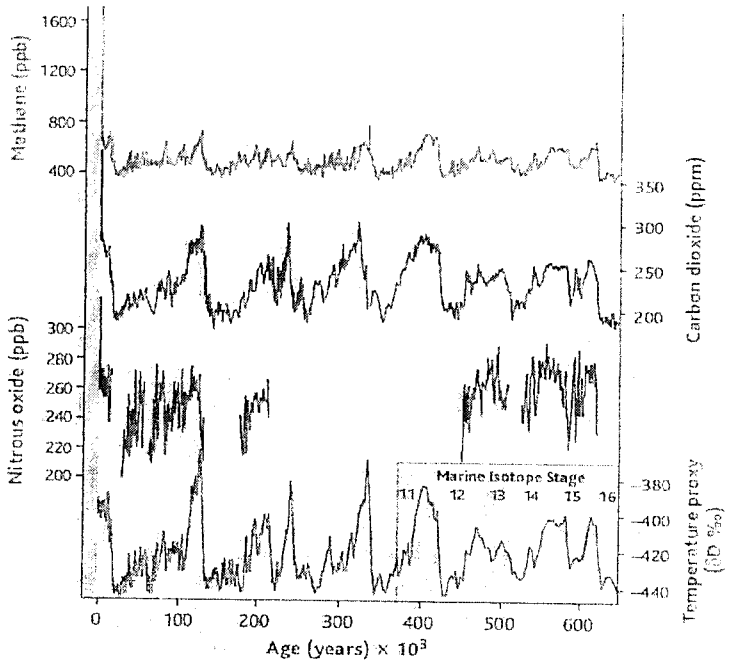
Candidate Number

Marks

Question 22 (4 marks)

Consider the data on the greenhouse gases presented in the graph below.

The greenhouse gas and deuterium (δD) records for the past 650,000 years from ice cores. δD, the deviation of the deuterium/hydrogen ratio from an isotope standard, is a proxy for air temperature; more positive values indicate warmer conditions.



(a) Which gas was most abundant in the atmosphere 500 000 years ago? **1**

CO_2

(b) Write chemical formulas for the three gases. **1**

N_2O, CO_2, CH_4

(c) Assess the validity of the claim that these three gases are greenhouse gases. **2**

Validity – supported by data presented

Identify graph feature (1 mark)

Identify feature (correlation between peaks) and identify if this feature supports the claim (2 marks)

Class Candidate Number

Marks

Question 23 (4 marks)

Discuss the use of neutralisation in dealing with an acid spill in a laboratory. **4**

Identify a problem caused by spilt acid e.g. corrosion.

Identify the need for safe clean up

Identify the need for safe disposal (environment)

Discuss one method that meets these criteria

Identify one method and explain why it is chosen

And an appropriate neutralising agent

Class

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Marks

Question 24 (4 marks)

One acidic oxide found in the atmosphere is $SO_{2(g)}$.

(a) Name one natural and one industrial source of $SO_{2(g)}$. **1**

Must have both e.g. natural – volcano

Industrial – fossil fuel combustion

(b) Write an equation to demonstrate the acidic nature of $SO_{2(g)}$. **1**

$SO_{2(g)} + H_2O_{(l)} \rightarrow H_2SO_{3(aq)}$

(c) At 25°C and 100kPa, what volume of $SO_{2(g)}$ would be needed to produce 500mL of 1.05M sulfurous acid? **2**

$n(SO_2) = n(H_2SO_3) = 0.500 \times 1.05$ (1 mark)

$V(SO_2)$ at 25°C and 100kPa

$= 0.500 \times 1.05 \times 24.19L$

$= 13.0L$ (1 mark)

Class Candidate Number

Marks

Question 25 (5 marks)

In an experiment to determine the ammonia concentration in a bottle of cloudy ammonia, a student transferred a 25.00mL aliquot of cloudy ammonia to a 250.0mL volumetric flask and made it up to 250.0 mL with deionised water. The contents of this volumetric flask were thoroughly mixed. The student then titrated 25.00mL aliquots of this solution against 0.2530M HCl and obtained an average titre volume of 22.50mL. Assume the density of the ammonia solution is 0.950 g/mL.

Calculate the concentration of NH_3 in the cloudy ammonia as %w/w (grams per 100g of solution). **5**

$NH_{3(aq)} + H^+_{(aq)} \rightarrow NH_4^+{}_{(aq)}$ *(1 mark)*

$n(NH_3)_{dil} = n(HCl) = 0.02250 \times 0.2530 mol$ *(2 marks)*

$[NH_3]_{undil} = \dfrac{0.02250 \times 0.2530}{0.02500} \times 10 = 2.277M$ *(3 marks)*

$conc(NH_3) = 2.277 \times 17.034 = 38.79 g/L$ *(4 marks)*

$\dfrac{38.79}{950} \times 100 = 4.08\% w/w$ *(5 marks)*

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Class Candidate Number

Marks

Question 26 (7 marks)

Chemical monitoring of the concentrations of ions such as Mg^{2+}, Ca^{2+}, NO_3^-, PO_4^{3-} is important to manage the quality of water resources.

For one cation and one anion from the list above:

(a) Identify a possible source and state whether the source is natural or a result of human activity. **2**

Correctly identifies one cation, source; natural (1 mark)

Correctly id one cation and one anion AND specific sources; natural/not (2 marks)

(b) Explain why monitoring and management of the concentrations of the two ions you have chosen is important. **2**

ID 'water hardness' AND 'eutrophication'

OR ID one of the above and explain } *(1 mark)*

ID AND explains problems caused by hardness and eutrophication (2 marks)

(c) Discuss the range and chemistry of tests used to monitor one of the ions you have chosen. **3**

ID one specific test OR explain that different conditions/concs require different tests (1 mark)

ID one test AND its range OR chemistry (2 marks)

ID two tests (one specific) AND range AND chemistry (3 marks)

Class Candidate Number

Marks

Question 27 (8 marks)

Human activity has caused changes in the composition and structure of the atmosphere.

(a) Identify the origins of CFCs and halons in the atmosphere. **1**

ID CFCs and halons as anthropogenic (1 mark)

(b) Explain the impacts of CFCs and halons on the atmosphere. **4**

ID gases as GHG (greenhouse gas) OR ozone depleting (1 mark)

ID gases as GHG AND O_3 depleting

OR ID gases such as O_3 depleting AND explains problems caused } (2 marks)

AND

Relates GHG OR O3 destruction to properties of CFCs/halons (3-4 marks)

Question 27 continued on next page.

Class Candidate Number

Question 27 continued

Marks

(c) Assess the measures being taken to alleviate the problems associated with CFCs. **3**

ID search for replacements (HCFC or HFC) and international protocols (1 mark)

Assesses one measure (1-2 marks)

Assesses two measures (2-3 marks)

Distinguish clearly between O_3 depletion and Global Warming

NB: Kyoto protocol : GHG

Montreal (Vienna, Copenhagen) : CFC

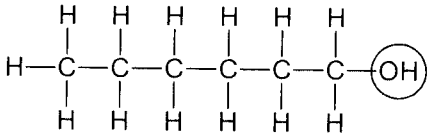
Class

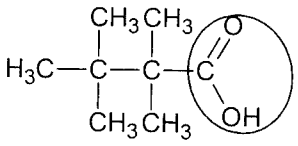
Candidate Number

Marks

Question 28 (8 marks)

(a) Draw the structural formulas of 1-hexanol and propanoic acid. Circle and name the functional groups in these molecules. **2**





Hydroxyl (alcohol)

carboxylic acid (-oic acid)

Must show all atoms and all bonds

(b) 1-hexanol and 3,3-dimethyl-1-butanol are isomers. Explain why 1-hexanol has a higher boiling point than 3,3-dimethyl-1-butanol. **2**

ID dispersion forces between hexanol molecules stronger than those between butanol (1 mark)

EXPLAINS difference in bp (1-2 marks)

NB: butanol is more dense than 1-hexanol

0.844g/mL vs 0.814g/mL

(c) Draw a fully labelled diagram of the apparatus needed to esterify 1-hexanol and propanoic acid in a school laboratory. **2**

Correctly drawn apparatus and safe heating

Labels must include "condenser", "H_2O in", "H_2O out" and safe heating method

NB: water bath boils at 100°C. will not allow heating under reflux for this esterification.

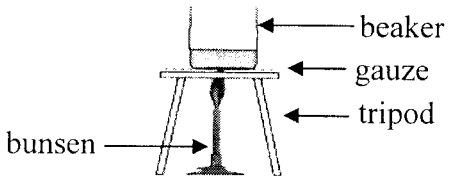
Question 28 continued on next page.

Class Candidate Number

Question 28 continued

Marks

(d) Explain why the apparatus you drew in (c) would be more appropriate than the apparatus below. **2**



ID two features or explains one feature (1 mark)

ID volatility and flammability AND explains problems (2 marks)

NB: "explosion" etc very popular when 'ignite', 'catch fire' etc would be better

BP: hexanol 158°C

Propanoic acid 140°C

Ester 190°C

Water 100°C

H_2SO_4 337°C

Class

Candidate Number

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Class Candidate Number

Marks

Question 29 (8 marks)

It has been said that in the 21st century wars will be fought for access to natural resources such as oil and water, and some people feel that this has already begun. **8**

Discuss the need for alternative sources of the compounds presently obtained from petrochemicals and evaluate the effect that using these alternative sources will have on environmental concerns such as global warming.

Problems associated with current use:

- *identifies one problem (1 mark)*
- *named derivative and one problem*
- *identifies two problems* } *(2 marks)*
- *explains one problem*
- *discusses two or more problems (3 marks)*

Alternative Sources:

- *identifies an alternative source (1 mark)*
- *identifies two alternative sources* } *(2 marks)*
- *gives details about production process (i.e equation/bacteria name of alternative)*

Critical evaluation of effects of alternative use:

- *identifies an effect on an environmental concern (1 mark)*
- *identifies two effects or discusses one (2 marks)*
- *critically evaluates 2 or more effects of alternative sources use on environmental concerns (3 marks)*

Section II

Class | Candidate Number

16 marks
Attempt question 30 in this section.
Allow about 35 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.
Show **all** relevant working in questions involving calculations.

		Pages
Question 30	**Industrial Chemistry**	**27**
Question 31	**Elective 2**	
Question 32	**Elective 3**	
Question 33	**Elective 4**	
Question 34	**Elective 5**	

Class Candidate Number

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Class Candidate Number

Marks

Question 30 (16 marks)

(a) Most sulfuric acid is manufactured on the industrial scale using the Contact process which involves the conversion of sulfur dioxide gas into sulfur trioxide gas.

(i) Write a chemical equation for this reaction and an expression for the equilibrium constant, K. **1**

$2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$K = [SO_3]^2/[SO_2]^2[O_2]$ } *both for 1 mark*

(ii) How does an increase in pressure affect the value of the equilibrium constant? **1**

Pressure does not affect K

(b) Nitrogen dioxide is a poisonous brown gas which may be involved in the production of photochemical smog. **4**

In an experiment 5.0 mol of dinitrogen tetraoxide were added to a 20L vessel and the system reached equilibrium. At equilibrium 3.8 mol of dinitrogen tetraoxide remained. Calculate the equilibrium constant, K, for this reaction:

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

Initial n	*5.0*	*0 (1 mark)*
At equilibrium n	*3.8*	*(5.0-3.8)2 = 2.4*
At equilibrium [] mol/L	$\frac{3.8}{20}$	$\frac{2.4}{20}$
	(0.19)	*(0.12) (1 mark)*

$K = [NO_2]^2/[N_2O_4]$ (1 mark)

$= (0.12)^2/0.19 = 7.6 \times 10^{-2}$ (1 mark)

Class Candidate Number

(c) (i) Describe one reaction in which concentrated sulfuric acid is acting as an oxidant. Include a relevant chemical equation. **2**

A correct equation (1 mark)

Description of reaction explaining redox (1 mark)

'Bare' equation and little or no desription (1 mark)

'Best' examples

oxidation state

$$\overset{-1}{2KI_{(s)}} + \overset{+6}{2H_2SO_{4(l)}} \rightarrow \overset{0}{I_{2(s)}} + K_2SO_{4(aq)} + \overset{+4}{SO_{2(g)}} + 2H_20_{(l)}$$

purple vapour/dark solid

(ii) Describe one reaction in which concentrated sulfuric acid is acting as a dehydrating agent. Include a relevant chemical equation. **2**

Easiest example dehydration of sucrose or glucose and black cone of carbon, like pumice (1 mark)

$$C_{12}H_{22}O_{11(s)} \xrightarrow[H_2SO_4]{conc} 12C_{(s)} + 11H_2O_{(l)}$$ *(1 mark)*

Class Candidate Number

(d) During your practical work you have performed a first-hand investigation to analyse the effect of disturbing an equilibrium reaction.

(i) Outline the procedure you used in this investigation. **3**

Equation for equilibrium system (1 mark)

Identify 3 disturbances in system and how these changes were detected (2 marks)

Best systems:

$Co^{2+}_{(aq)} + 4Cl^-_{(aq)} \rightleftharpoons CoCl_4^{2-}{}_{(aq)}$
pink *blue*

$Fe^{3+}_{(aq)} + CNS^-_{(aq)} \rightleftharpoons FeCNS^{2+}_{(aq)}$
yellow *colourless* *blood red*

(ii) Explain how you analysed the equilibrium reaction in a qualitative way. **3**

Control must be mentioned (1 mark)

Change in system identified – 3 disturbances (1 mark)

Changes explained in terms of Le Chatelier's principle

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Candidate Number

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Data Sheet

Avogadro's constant, N_A		6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas:	at 100 kPa and	
	at 0 °C (273 K)	22.71L
	at 25 °C (298K)	24.79 L
Ionisation constant for water at 25°C (298.15 K), K_w		1.0×10^{-14}
Specific heat capacity of water		4.18×10^3 Jkg^{-1}K^{-1}

Some useful formulae

$pH = -\log_{10}[H^+]$ $\Delta H = -mC\Delta T$

Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K_{(s)}$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba_{(s)}$	–2.91 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
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al_{(s)}$	–1.68 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
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe_{(s)}$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni_{(s)}$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn_{(s)}$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb_{(s)}$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_{2(g)}$	0.00 V
$SO_4^{2-} + 4H^+ + 2e$	$\rightleftharpoons$	$SO_{2(g)} + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.34 V
$\frac{1}{2} O_{2(g)} + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.52 V
$\frac{1}{2} I_{2(s)} + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2} I_{2(aq)} + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag_{(s)}$	0.80 V
$\frac{1}{2} Br_{2(l)} + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2} Br_{2(aq)} + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2} O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_{2(g)} + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2} Cl_{2(aq)} + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2} F_{2(g)} + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number 79 — Symbol of element: Au

Atomic Weight 197.0 — Name of element: Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	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 22.99 Sodium	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 39.10 Potassium	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 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	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 [97.91] 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 132.9 Caesium	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 [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89□103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [266.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [144.9] 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 [244.1] Plutonium	95 Am [243.1] Americium	96 Cm [247.1] Curium	97 Bk [247.1] Berkelium	98 Cf [251.1] 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.