SYDNEY GRAMMAR SCHOOL

2004
FORM VI
TRIAL HSC EXAMINATION

Chemistry

Total marks (100)

Section I Pages 2 - 20

This section has two parts, Part A and Part B

Part A
Total marks **(15)**
- Attempt Questions 1 - 15
- Allow about 30 minutes for this Part

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

Section II Pages 21 - 28
Total marks **(16)**
- Attempt ONE Question from Questions 30 - 34
- Allow about 30 minutes for this Section

General Instructions

- 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 student number at the top of pages 7, 11, 15 and 19

CHECKLIST	
Each boy should have the following:	
1 Question Paper	
1 Multiple Choice Answer Sheet	
1 4-page Writing Booklet	

1 - MMB	2 - AKBB	3 - JAG	
4 - AKBB	5 - PRT	6 - JAG	7 - EPC

Part A

Total marks (15)
Attempt ALL Questions
Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

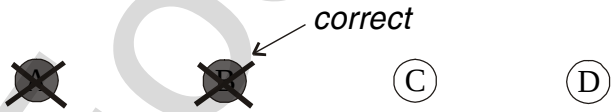
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

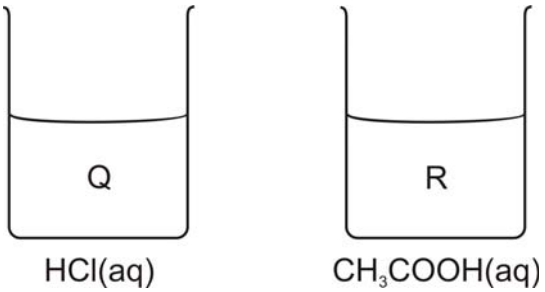
(A) 2 (B) 6 (C) 8 (D) 9

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



Solution Q is a solution of hydrochloric acid (pH = 2.5), while solution R is a solution of acetic (ethanoic) acid (pH = 2.5).
Based on the above information and your knowledge of acids, which of the following statements is correct?

(A) Solution R is stronger than solution Q.
(B) Solution R is more concentrated than solution Q.
(C) Solution Q is more concentrated than solution R.
(D) Solution Q contains more $H^+(aq)$ than solution R.

2 Which of the following statements about ozone is valid?

(A) Ozone depletion occurs only in the atmosphere above the South Pole.
(B) Ozone is a vital gas in the stratosphere.
(C) Ozone is a linear molecule.
(D) Ozone is destroyed only by chlorofluorocarbons.

3 Which of the following types of radiation is the most penetrating?

(A) α
(B) β
(C) γ
(D) $^{1}_{0}n$

4 At what point is equilibrium reached in a reversible reaction?

(A) When reactants stop changing into products.
(B) When the molar concentrations of reactants and products are constant.
(C) When the molar concentrations of reactants and products are equal.
(D) When the activation energy of the forward and backward reactions are the same.

5 A boy wished to classify lemon juice according to its acid/base characteristics. To do this he diluted some lemon juice and then added three drops of bromothymol blue. What colour would you expect this indicator to be in dilute lemon juice?

(A) Red
(B) Yellow
(C) Blue
(D) Colourless

6 Which of the following is the most common anode in commercial primary galvanic cells?

(A) Zinc
(B) Mercury(II) oxide
(C) Manganese dioxide
(D) Lead

7 Which of the following pairs of aqueous solutions will produce a precipitate on mixing?

(A) Sodium chloride and potassium nitrate
(B) Lead(II) chloride and potassium nitrate
(C) Potassium carbonate and barium nitrate
(D) Copper(II) sulphate and sodium chloride

8 What is the common name for 2-hydroxypropane-1,2,3-tricarboxylic acid?

(A) Acetic acid
(B) Hydrochloric acid
(C) Sulphuric acid
(D) Citric acid

9 Consider the following data:

Half-reaction	$E°_{red}$ / V
$W^+ + e^- \rightarrow W$	2.3
$X^{3+} + e^- \rightarrow X^{2+}$	0.7
$Y^{2+} + 2e^- \rightarrow Y$	-0.7
$Z^{2+} + 2e^- \rightarrow Z$	-1.7

Using the data above, which of the following is the best reducing agent?

(A) W
(B) W^+
(C) Z^{2+}
(D) Z

10 Which of the following needs to be monitored by industrial chemists working in coal-fired power stations?

(A) Electricity generated by the station.
(B) Rate of formation of ammonia from its elements.
(C) Emission of steam and carbon dioxide.
(D) Emission of carbon monoxide and sulphur dioxide.

11 Which of the following will affect the amount of hydrogen iodide gas present at equilibrium in this reaction?

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(A) Adding a catalyst.
(B) Adding an inert gas.
(C) Increasing the pressure.
(D) Increasing the temperature.

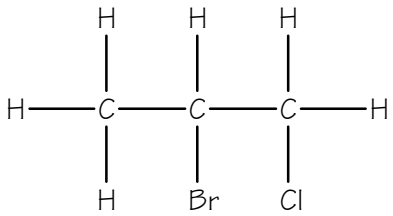
12 Which of the following is the most commercially significant addition polymer?

(A) Nylon
(B) PVC
(C) PET
(D) Starch

13 Which of the following statements about neutralization is correct?

(A) Neutralization is an electron transfer and is endothermic.
(B) Neutralization is an electron transfer and is exothermic.
(C) Neutralization is a proton transfer and is endothermic.
(D) Neutralization is a proton transfer and is exothermic.

14 What is the IUPAC name of the following compound?



(A) 2-bromo-3-chloropropane
(B) 1-chloro-2-bromopropane
(C) 2-bromo-1-chloropropane
(D) 2-chloro-2-bromopropane

15 In the nuclear transformation below, what is X?

$$^{10}_{5}\mathrm{B} + \alpha \rightarrow {}^{13}_{7}\mathrm{N} + \mathrm{X}$$

(A) An electron
(B) A proton
(C) A neutron
(D) A positron

Class

Student 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

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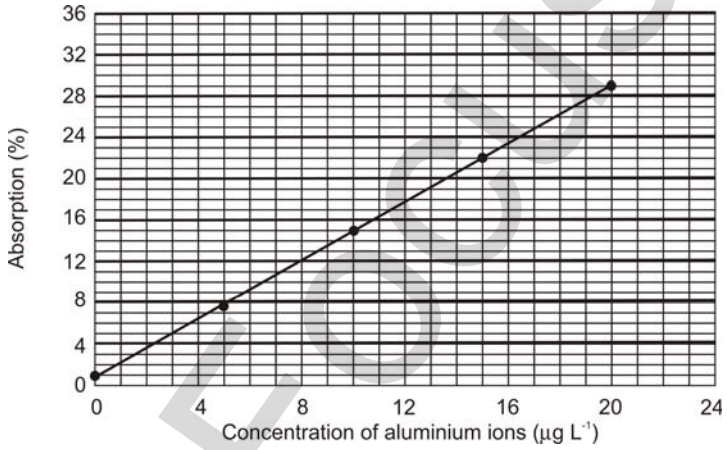
Marks

Question 16 (2 marks)

Atomic absorption spectroscopy (AAS) can be used as an analytical tool for finding the concentration of elements in the ppm range. The graph below shows the relationship of absorption against concentration of aluminium ions. **2**



Use this graph to determine the Al^{3+} concentration in ppm for a sample which registered an absorption of 10%.

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Marks

Question 17 (6 marks)

The equation $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ represents the synthesis of ammonia from its component gases and is known as the Haber process.

(a) Describe the geo-political conditions under which Haber developed the industrial synthesis of ammonia and evaluate its significance at this time in world history. **3**

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

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Marks

Question 18 (5 marks)

Atomic absorption spectroscopy (AAS) is an extremely useful tool in the detection of metal ion concentrations.

(a) Explain why AAS is of little use in identifying unknown substances. **3**

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(b) Explain how AAS has had a major impact on the scientific understanding of the effects of trace elements. **2**

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Marks

Question 19 (6 marks)

The fermentation of glucose is a chemical process which has been known to humans for at least 5 thousand years.

(a) Write a chemical equation to represent the fermentation of glucose. **2**

(b) Under what physical conditions is fermentation optimised? **1**

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(c) One of the products of the fermentation process is frequently used as a solvent for both polar and non-polar solutes. Account for ethanol's ability to do this. **3**

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Section I – Part B (continued)

Class

Student Number

Marks

Question 20 (5 marks)

Fossil fuels, which at present make up the bulk of the raw material used in the plastics industry, are a finite resource and likely to become severely depleted in the near future. Biopolymers have been suggested as a possible replacement for the petrochemicals produced from fossil fuels.

(a) Cellulose is often considered the most useful compound from which to produce biopolymers. Describe the structure of cellulose. **2**

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(b) (i) Identify a biopolymer which has recently been developed or is in the process of being developed, for commercial use. **1**

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(ii) Name the specific enzyme or organism used to synthesise this biopolymer. **1**

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(c) Suggest one benefit (apart from their renewability), of using biomass to produce polymers. **1**

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Marks

Question 21 (3 marks)

(a) Draw electron dot diagrams to show:

(i) an oxygen molecule. **1**

(ii) an ozone molecule. **1**

(b) State the difference in stability of ozone gas and oxygen gas. **1**

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Marks

Question 22 (3 marks)

Esters are produced by reaction of an alkanoic acid and an alcohol.

(a) Name a straight-chained alkanoic acid. **1**

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(b) Name a primary alcohol. **1**

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(c) Name the ester that would be produced by refluxing this acid with this alcohol. **1**

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Marks

Question 23 (7 marks)

Over time, the definitions of acids and bases have been refined. Using the historical development of ideas about acids, evaluate how advances in scientific understanding changed the direction of scientific thinking. **7**

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Section I – Part B (continued)

Class

Student Number

Marks

Question 24 (5 marks)

A student was investigating the acid/base nature of salts, by adding the dry solid salts one at a time to water and then testing their pH.

When he did this with ammonium chloride, he noted that the pH < 7, and assumed that the following action had occurred.

$$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+$$

(a) Why does the above equation illustrate a Brönsted-Lowry acid, rather than an Arrhenius acid? **2**

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(b) From the above equation, give one example of an acid and its conjugate base, respectively. **1**

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(c) Briefly outline how you would perform a first-hand investigation to determine the concentration of an acidic substance using a computer-based technology. **2**

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Marks

Question 25 (3 marks)

(a) Identify two metallic ions which are found in hard water. **1**

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(b) Describe a simple method of determining the hardness of water in a school laboratory. **2**

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Marks

Question 26 (6 marks)

While we usually think of the air around us as neutral, the atmosphere naturally contains acidic oxides of carbon, nitrogen and sulfur.

(a) (i) Describe, using an equation, an example of a chemical reaction which releases sulfur dioxide. **2**

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(ii) Identify a natural source of sulfur dioxide. **1**

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(b) (i) Describe, using an equation, an example of a chemical reaction which releases an oxide of nitrogen. **2**

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(ii) Identify a natural source of nitric oxide (NO), a gas that is capable of destroying ozone, and is involved in the production of photochemical smog. **1**

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Section I – Part B (continued)

Class

Student Number

Marks

Question 27 (4 marks)

(a) Discuss the conditions under which nuclei are stable. **2**

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(b) The two equations below represent the formation of significant artificial isotopes: **2**

$^{98}_{42}\text{Mo} + ^{1}_{0}\text{n} \rightarrow ^{99}_{42}\text{Mo} \rightarrow ^{99}_{43}\text{Tc} + ^{0}_{-1}\beta$

$^{14}_{7}\text{N} + ^{1}_{1}\text{H} \rightarrow ^{11}_{6}\text{C} + ^{4}_{2}\text{He}$

Tc-99 is the most widely used radioactive isotope for diagnostic studies in nuclear medicine. C-11 is incorporated into organic compounds and used as a tracer in positron emission tomography (PET).

Discuss the production of commercial isotopes using these and / or other relevant examples.

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Marks

Question 28 (6 marks)

Galvanic cells were constructed using the metals A – E and the voltages measured under standard conditions. The results are shown in the table below.

Cell reaction	**$E°_{cell}$ / V**
$A + B^{2+} \rightarrow A^{2+} + B$	0.98
$B + D^{2+} \rightarrow B^{2+} + D$	1.05
$2C + B^{2+} \rightarrow 2C^{+} + B$	1.68
$B + B^{2+} \rightarrow B^{2+} + B$	0.00
$B + E^{2+} \rightarrow B^{2+} + E$	0.66

(a) Draw a labelled diagram of one of the cells used and identify clearly the reference cell. **3**

(b) Explain what is meant by standard conditions. **1**

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Question 28 continued on page 21

Marks

Question 28 (continued)

(c) Construct a table of standard (half-cell) potentials from the data collected. **1**

(d) (i) Identify the best reducing agent. **1**

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(ii) Identify the best oxidising agent.

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Marks

Question 29 (8 marks)

Polyethylene is a chemical which has been of significant commercial importance in the past fifty years.

(a) Outline the major steps in the industrial production of polyethylene, from the raw material used, to the finished product. **3**

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(b) Many commercial polymers are produced by the modification of ethene molecules, such that a hydrogen is replaced by a side group, followed by a polymerisation reaction.

(i) Identify one such "modified ethene" monomer, either by its common or systematic name, and using complete structural formula, write an equation to represent the polymerisation reaction, using **three** monomer units. **3**

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Question 29 continued on page 23

Marks

Question 29 (continued)

(ii) Describe a use for the polymer you have identified, in part (i), in terms of its physical or chemical properties. **2**

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Section II

Total marks (16)
Attempt ONE question from Questions 30 - 33
Allow about 30 minutes for this Section

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

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Marks

Question 30 - Industrial Chemistry (16 marks)

(a) Industrial chemists have researched and developed replacements for some natural products.

(i) Identify one dwindling natural resource that is not a fossil fuel. **1**

(ii) Name a material that has been manufactured to replace the natural product identified in part (i). **1**

(iii) Explain why this replacement material is now manufactured. **1**

(b) (i) Describe the use of sulphuric acid as a dehydrating agent. **1**

(ii) Explain how sulphuric acid may be used as an oxidant. **2**

(c) Phosgene, or carbonyl chloride, $COCl_2$, is a colourless, poisonous gas used in the production of some polymers. Carbonyl chloride decomposes as shown in the following equation. **3**

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

1.00 mol of carbonyl chloride was placed in a 10.0 L sealed flask at 1250°C. At equilibrium 0.20 mol of carbonyl chloride was present in the flask. Calculate the value of the equilibrium constant for the decomposition of carbonyl chloride at 1250°C.

(d) Chemistry laboratories buy 18M (concentrated) sulphuric acid and dilute this so that they are able to make the concentrations needed for day-to-day analysis. **3**

Explain how you would **safely** dilute 18M sulphuric acid to make 2M sulphuric acid. Include safety precautions.

(e) Sulfuric acid is such an important chemical in industry that its annual production may be used as an index of a nation's industrial activity. **4**

Explain why sulphuric acid is such an important industrial chemical using three different industrial uses of sulphuric acid.

End of Question 30

Marks

Question 33 - Chemistry of Art (16 marks)

(a) Modern cosmetics are carefully formulated to be beneficial to the skin, or at least not harmful, but this was not always the case. Some of the pigments used in ancient Egyptian, Greek and Roman make-up are given below.

Face make-up	White lead	$2PbCO_3.Pb(OH)_2$
Lipstick	Cinnabar	HgS
Eye-shadow	Orpiment	As_2S_3
Mascara	stibnite	Sb_2S_3

(i) What is the modern systematic name for orpiment? **1**

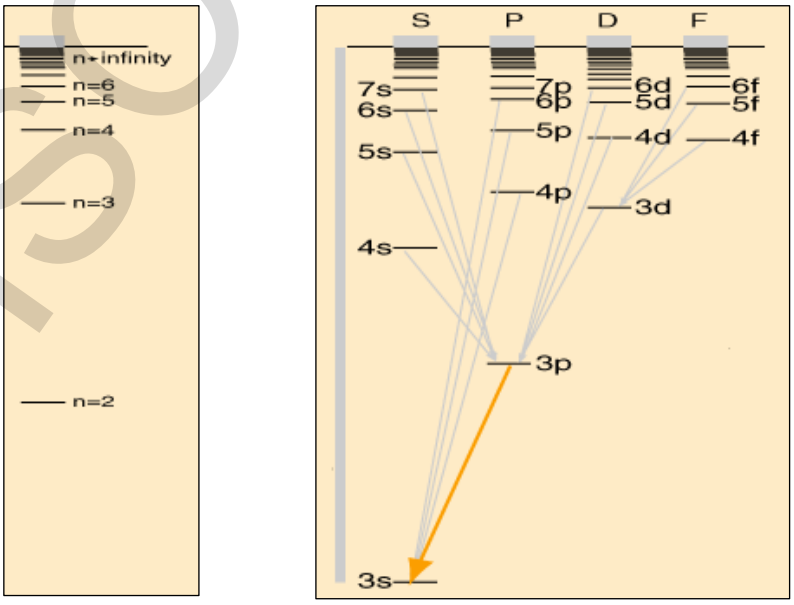
(ii) What are some of the safety hazards associated with these pigments? **2**

(b) (i) Identify the components of a paint. **1**

(ii) Outline the processes and chemistry involved to prepare and attach pigments to surfaces in a named example of a medieval or earlier artwork. **2**

(c) Explain the relationship between UV/visible absorption and reflectance spectra. **3**

(d) Explain the main features of atomic absorption and emission spectra, making reference to the energy level diagrams for sodium and hydrogen (see below). **3**



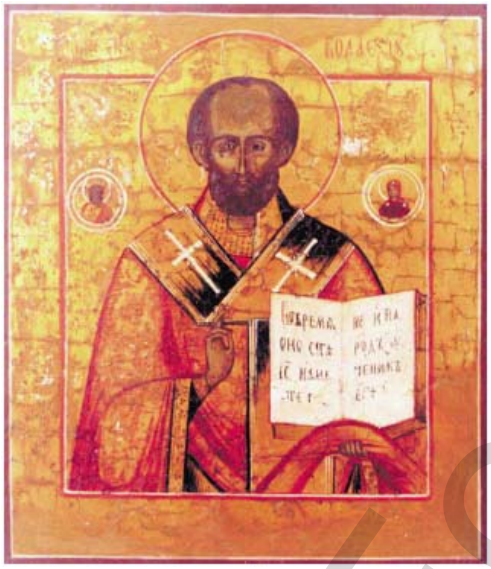
Question 33 continues on page 29

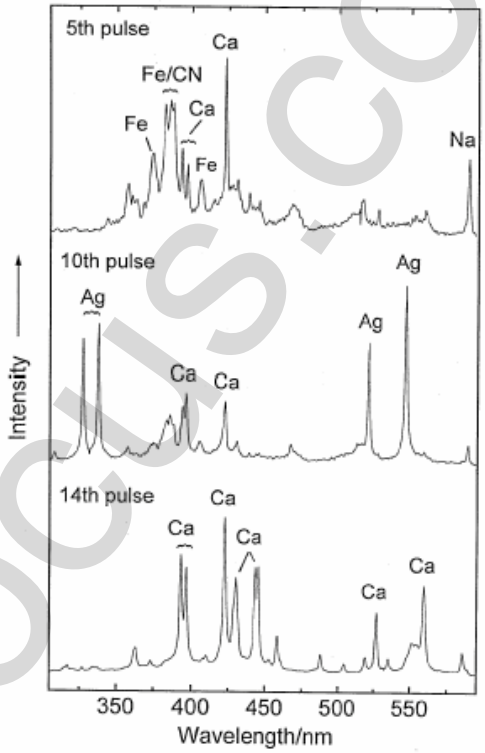
Marks

Question 33 (continued)

(e) In laser microspectral analysis (LMA) a high energy laser pulse vaporises a minute amount of the material. Consecutive pulses dig deeper and deeper into the artwork, so that depth profiling is possible. The technique is very sensitive, using samples as small as 10^{-7} g. It may also be coupled with other techniques that can identify the individual pigments. **4**

Russian icon of St Nicholas





The results of one LMA experiment on a nineteenth century Russian icon are shown above. A brown pigment in the paint is separated from the white ground by a metallic layer; the backing is wood.

Analyse the results and suggest compositions for the components of the three layers. Justify your answer.

End of Question 33

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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
Au
Atomic Weight
197.0
Gold
Symbol of element
Name of element

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 65.39 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 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 [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 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 [210.0] 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 [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.