



# 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

☐ (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)*correct* →☐ (C)☐ (D)

1 What is a free radical?

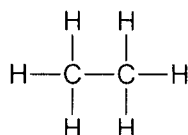
- (A) An atom or molecule with an unpaired electron.
- (B) A particle that is free to move in a chemical reaction.
- (C) A charged particle that is free to move.
- (D) An organo-halogen compound.

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

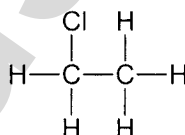
- (A) iron-iron oxide
- (B) zeolite
- (C) conc  $\text{H}_2\text{SO}_4$
- (D)  $\text{V}_2\text{O}_5$

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

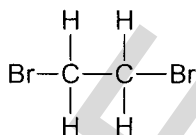
(A)



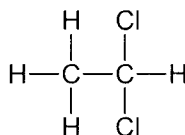
(B)



(C)



(D)



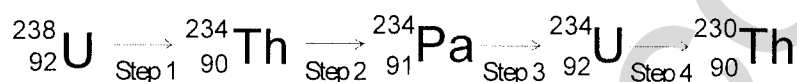
4 Which of the following statements best describes condensation polymerisation?

- (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;  $\approx 35^{\circ}\text{C}$ .  
 (B) Conc.  $\text{H}_2\text{SO}_4$  is added; zymase(yeast) is present;  $\approx 35^{\circ}\text{C}$ .  
 (C) Mixture is oxygenated; zymase(yeast) is added;  $\approx 25^{\circ}\text{C}$ .  
 (D) Low  $\text{O}_2$  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:

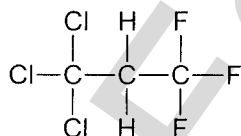


The types of radiation which accompany each of steps 1 to 4, are respectively-

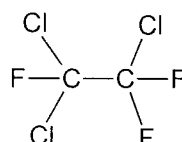
(A)  $\beta$ ,  $\alpha$ ,  $\alpha$ ,  $\beta$   
 (B)  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$   
 (C)  $\alpha$ ,  $\beta$ ,  $\beta$ ,  $\alpha$   
 (D)  $\beta$ ,  $\gamma$ ,  $\gamma$ ,  $\beta$

- 7 Which of the compounds below are isomers?

(I)



(II)

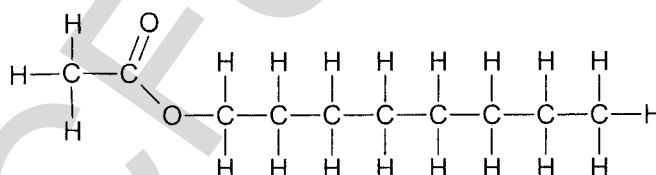


(III) 1,1,1-trichloro-2,2,2-trifluoroethane

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

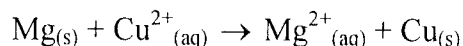
(A) (I) and (IV)  
 (B) (II) and (III)  
 (C) (I) and (II)  
 (D) (III) and (IV)

- 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  $\text{HCl}_{(\text{aq})}$  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  $\text{H}^+$  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)  $\text{NH}_4\text{Cl}$   
(B)  $\text{KNO}_3$   
(C)  $\text{KCH}_3\text{CH}_2\text{COO}$   
(D)  $\text{FeCl}_3$

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



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  $\text{HCl}_{(aq)}$
  - (B) 20.0mL of 0.40M  $\text{HCl}_{(aq)}$
  - (C) 30.0mL of 0.30M  $\text{HCl}_{(aq)}$
  - (D) 40.0mL of 0.20M  $\text{HCl}_{(aq)}$
- 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.

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

Class

Candidate Number

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

.....

.....

.....

.....

.....

.....

**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

<b>Titrant</b>	<b>Other reactant</b>	<b>Appropriate indicator</b>
HCl	NaOH	
CH <sub>3</sub> COOH	LiOH	
NH <sub>3</sub>	HNO <sub>3</sub>	



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**

.....

.....

Class

Candidate Number

**BLANK PAGE**

HSCFocus.com

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**

.....

.....

.....

.....

.....

.....

**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**

.....

.....

.....

.....

.....

.....

Class

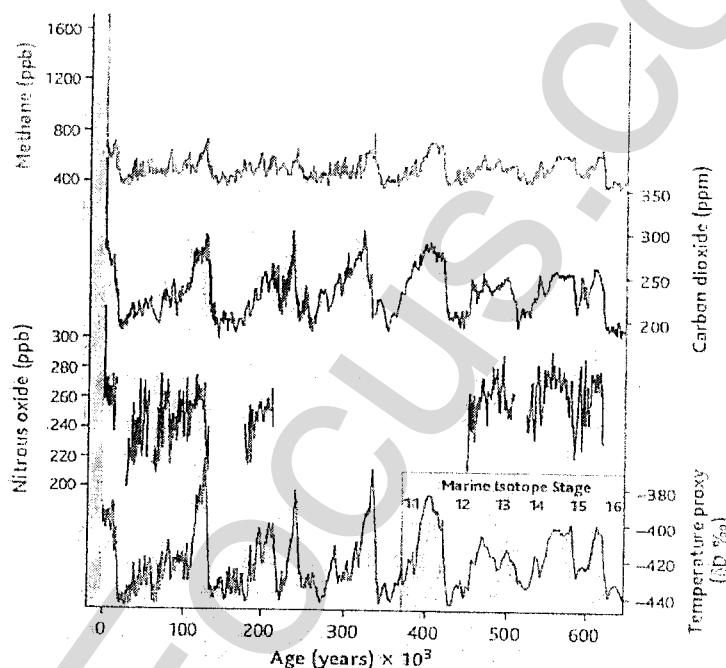
 Candidate Number

Marks

**Question 22** (4 marks)

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

The greenhouse gas and deuterium ( $\delta D$ ) records for the past 650,000 years from ice cores.  $\delta D$ , 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

.....

- (b) Write chemical formulas for the three gases.

1

.....

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

2

.....

.....

.....

.....

Class

Candidate Number

**Marks****Question 23** (4 marks)

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

**4**

.....

.....

.....

.....

.....

.....

.....

.....

Class

Candidate Number

Marks

**Question 24** (4 marks)

One acidic oxide found in the atmosphere is  $\text{SO}_{2(g)}$ .

- (a) Name one natural and one industrial source of  $\text{SO}_{2(g)}$ .

1

.....

.....

- (b) Write an equation to demonstrate the acidic nature of  $\text{SO}_{2(g)}$ .

1

- (c) At  $25^{\circ}\text{C}$  and  $100\text{kPa}$ , what volume of  $\text{SO}_{2(g)}$  would be needed to produce  $500\text{mL}$  of  $1.05\text{M}$  sulfurous acid?

2

.....

.....

.....

.....

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  $\text{NH}_3$  in the cloudy ammonia as %w/w (grams per 100g of solution).

**5**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Class

Candidate Number

**BLANK PAGE**

HSCFocus.com



Class

Candidate Number

Marks

**Question 26** (7 marks)

Chemical monitoring of the concentrations of ions such as  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$  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

.....

.....

.....

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

.....

.....

.....

.....

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

.....

.....

.....

.....

.....

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**

.....

.....

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

**4**

.....

.....

.....

.....

.....

.....

.....

.....

.....

**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**

.....

.....

.....

.....

.....

.....

HSCFocus.com

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

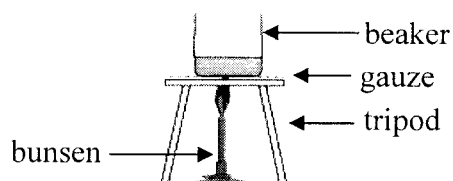
**Question 26 continued on next page.**

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**

.....

.....

.....

.....

Class

Candidate Number

**BLANK PAGE**

HSCFocus.com

Class

Candidate Number

Marks

**Question 29** (8 marks)

It has been said that in the 21<sup>st</sup> 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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Class

Candidate Number

**BLANK PAGE**

HSCFocus.com



**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.

---

	<b>Pages</b>
<b>Question 30</b>	<b>Industrial Chemistry.....27</b>
<b>Question 31</b>	<b>Elective 2</b>
<b>Question 32</b>	<b>Elective 3</b>
<b>Question 33</b>	<b>Elective 4</b>
<b>Question 34</b>	<b>Elective 5</b>

Class

Candidate Number

**BLANK PAGE**

HSCFocus.com

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 tetroxide were added to a 20L vessel and the system reached equilibrium. At equilibrium 3.8 mol of dinitrogen tetroxide remained. Calculate the equilibrium constant,  $K$ , for this reaction:
- $$\text{N}_2\text{O}_{4(g)} \rightleftharpoons 2\text{NO}_{2(g)}$$
- (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

**BLANK PAGE**

HSCFocus.com

## Chemistry

## Data Sheet

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

## Some useful formulae

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

$$\Delta H = -mC\Delta T$$

## Standard Potentials

$\text{K}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{K}_{(\text{s})}$	-2.94 V
$\text{Ba}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ba}_{(\text{s})}$	-2.91 V
$\text{Ca}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ca}_{(\text{s})}$	-2.87 V
$\text{Na}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Na}_{(\text{s})}$	-2.71 V
$\text{Mg}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mg}_{(\text{s})}$	-2.36 V
$\text{Al}^{3+} + 3\text{e}^-$	$\rightleftharpoons$	$\text{Al}_{(\text{s})}$	-1.68 V
$\text{Mn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Mn}_{(\text{s})}$	-1.18 V
$\text{H}_2\text{O} + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2} \text{H}_{2(\text{g})} + \text{OH}^-$	-0.83 V
$\text{Zn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Zn}_{(\text{s})}$	-0.76 V
$\text{Fe}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Fe}_{(\text{s})}$	-0.44 V
$\text{Ni}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Ni}_{(\text{s})}$	-0.24 V
$\text{Sn}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Sn}_{(\text{s})}$	-0.14 V
$\text{Pb}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Pb}_{(\text{s})}$	-0.13 V
$\text{H}^+ + \text{e}^-$	$\rightleftharpoons$	$\frac{1}{2} \text{H}_{2(\text{g})}$	0.00 V
$\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{SO}_{2(\text{g})} + 2\text{H}_2\text{O}$	0.16 V
$\text{Cu}^{2+} + 2\text{e}^-$	$\rightleftharpoons$	$\text{Cu}_{(\text{s})}$	0.34 V
$\frac{1}{2} \text{O}_{2(\text{g})} + \text{H}_2\text{O} + 2\text{e}^-$	$\rightleftharpoons$	$2\text{OH}^-$	0.40 V
$\text{Cu}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Cu}_{(\text{s})}$	0.52 V
$\frac{1}{2} \text{I}_{2(\text{s})} + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.54 V
$\frac{1}{2} \text{I}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{I}^-$	0.62 V
$\text{Fe}^{3+} + \text{e}^-$	$\rightleftharpoons$	$\text{Fe}^{2+}$	0.77 V
$\text{Ag}^+ + \text{e}^-$	$\rightleftharpoons$	$\text{Ag}_{(\text{s})}$	0.80 V
$\frac{1}{2} \text{Br}_{2(\text{l})} + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.08 V
$\frac{1}{2} \text{Br}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{Br}^-$	1.10 V
$\frac{1}{2} \text{O}_2 + 2\text{H}^+ + 2\text{e}^-$	$\rightleftharpoons$	$\text{H}_2\text{O}$	1.23 V
$\frac{1}{2} \text{Cr}_2\text{O}_7^{2-} + 7\text{H}^+ + 3\text{e}^-$	$\rightleftharpoons$	$\text{Cr}^{3+} + \frac{7}{2} \text{H}_2\text{O}$	1.36 V
$\frac{1}{2} \text{Cl}_{2(\text{g})} + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.36 V
$\frac{1}{2} \text{Cl}_{2(\text{aq})} + \text{e}^-$	$\rightleftharpoons$	$\text{Cl}^-$	1.40 V
$\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$	$\rightleftharpoons$	$\text{Mn}^{2+} + 4\text{H}_2\text{O}$	1.51 V
$\frac{1}{2} \text{F}_{2(\text{g})} + \text{e}^-$	$\rightleftharpoons$	$\text{F}^-$	2.89 V

PERIODIC TABLE OF THE ELEMENTS

Atomic Number	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 65.41 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 Cesium	56 Ba 137.3 Barium	
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		
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 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		

KEY

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

## 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 Pu are given for the isotopes  $^{237}\text{Np}$  and  $^{244}\text{Pu}$ .