

# CRANBROOK SCHOOL

YEAR 12

TERM 3, 2001

## TRIAL HSC COURSE 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

#### Section I

Pages 2 - 10

#### Total marks (93)

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 (78)

- Attempt Questions 16 - 30
- Allow about 2 hours and 15 minutes for this part

#### Section II

Pages 11 - 12

#### Total marks (7)

- Attempt question 31
- Allow about 15 minutes for this section.

The content and format of this paper do not necessarily reflect the content and format of the HSC examination paper.

#### Section 1 Total marks (93)

#### Part A Total marks (15) Attempt Questions 1 - 15 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 in the response oval completely.

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

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

A ☒ B ☒ C ☐ D ☐

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

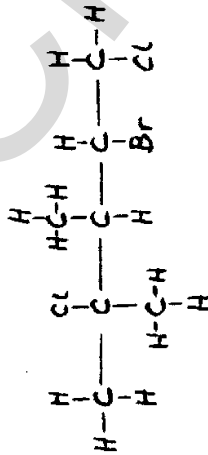
A ☒ B ☒ *correct* C ☐ D ☐

- Which of the following statements is correct?
  - Ethane has a higher MP than ethene due to weaker dispersion forces between ethane molecules
  - Ethane is less reactive than ethene and ethane undergoes addition reactions
  - Ethane and ethene are both polar molecules
  - Ethane is less reactive than ethene and ethane undergoes substitution reactions
- Polystyrene is best suited for:
  - carry bags due to its rigidity
  - tool handles due to its large side group
  - garden hoses due to its high melting point
  - carpets due to its ability to stretch and return to its original position
- Which underlined species is being oxidised in the following equations?
  - $4\text{Fe}_{(s)} + 3 \text{O}_{2(g)} \rightarrow 2\text{Fe}_2\text{O}_{3(s)}$
  - $\text{H}_2\text{SO}_{4(aq)} + 2\text{NaOH}_{(aq)} \rightarrow \text{Na}_2\text{SO}_{4(aq)} + 2\text{H}_2\text{O}_{(l)}$
  - $\text{Zn}_{(s)} + 2\text{HCl}_{(aq)} \rightarrow \text{ZnCl}_{2(aq)} + \text{H}_{2(g)}$
  - $\text{H}_{2(g)} + \text{Cl}_{2(g)} \rightarrow 2\text{HCl}_{(g)}$
- When refining a metal such as copper by electrolysis the:
  - impure copper is at the cathode
  - impure copper is the electrolyte
  - pure (refined) copper is the oxidant
  - pure (refined) copper undergoes oxidation
- The stability of isotopes is related to the ratio of neutrons to protons in the nucleus. Unstable nuclei of elements with:
  - a low atomic number mainly produce  $\beta$ -particles
  - an atomic number greater than 83 produce  $\alpha$ -particles only
  - an atomic number less than 83 produce  $\alpha$ -particles and  $\delta$ -radiation only
  - a neutron to proton ratio between 1 and 1.1 produce  $\delta$ -radiation only
- Acid strength is a measure of the:
  - concentration of an acid in solution
  - extent to which an acid neutralises a base
  - extent to which an acid ionises in water
  - number of acidic protons present in the acid molecule
- The preparation of phosgene,  $\text{COCl}_{2(g)}$ , is exothermic and can be represented by the equation:
 
$$\text{CO}_{(g)} + \text{Cl}_{2(g)} \leftrightarrow \text{COCl}_{2(g)} + \Delta$$
 The formation of phosgene would be most favoured by:
  - high temperature, high pressure and removal of phosgene
  - low temperature, low pressure and removal of chlorine
  - low temperature, high pressure and removal of phosgene
  - high temperature, low pressure and addition of carbon monoxide
- To indicate that a substance is slightly acidic and not highly acidic a scientist would best use a combination of which two indicators:
  - methyl orange and bromothymol blue
  - litmus and bromothymol blue
  - litmus and phenolphthalein
  - methyl orange and phenolphthalein
- The structure below represents:
 
$$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_2\text{CH}_2\text{CH}_3$$
  - propyl propanoate
  - propyl butanoate
  - butyl propanoate
  - butyl butanoate

10. In a titration of a strong base with a weak acid the solution at the equivalence point is:

(A) acidic  
(B) basic  
(C) neutral  
(D) dependent on the concentrations of the acid and base used

11. The systematic name for the compound shown below is:



(A) 2-bromo-1,4-dichloro-3,4-dimethylpentane  
(B) 4-bromo-2,5-dichloro-2,3-dimethylpentane  
(C) 3,4-dimethyl-4-bromo-2,5-dichloropentane  
(D) 1,3,4-trichloro-bromo-hexane

12. A particular chemical is found to exhibit the following properties:

- A brick-red flame colour
- A white precipitate with  $F^-$  ions
- A yellow precipitate with  $Pb^{2+}$  ions

The chemical is most probably:

(A)  $BaCl_2$   
(B)  $BaI_2$   
(C)  $CaCl_2$   
(D)  $CaI_2$

13. The rate of the following exothermic reaction can be increased by:



(A) decreasing the temperature  
(B) increasing the pressure  
(C) removing the product  
(D) adding a catalyst

14. AAS (Atomic Absorption Spectroscopy) could not be used to monitor:

(A) excessive chlorination of drinking water  
(B) micro-nutrients in soil  
(C) trace elements in living cells  
(D) the mercury content in fish

15. A gas is found to have the following properties:

- Colourless
- Condenses to a distinct blue liquid
- Strong odour
- Poisonous in very small proportions
- Used to sterilise water

The gas is most probably:

(A)  $CO_2$   
(B)  $O_2$   
(C)  $O_3$   
(D)  $H_2S$

## Section I

### Part B

Total marks (78)

Attempt Questions 16 - 30

Allow about 2 hours and 15 minutes for this part

Answer Questions 16 - 21 in the Part B1 Answer Booklet.

Answer Questions 22 - 30 in the Part B2 Answer Booklet

Show all relevant working in questions involving calculations.

#### Question 16 (5 marks)

Marks

Name a propellant that has been used as an alternative to CFC's (chlorofluorocarbons). Discuss why this propellant is favourable to chlorofluorocarbons.

5

#### Question 17 (3 marks)

- (a) Describe how the acidity/basicity of the oxides varies across period 3.
- (b) Write an equation for one of the oxides acting as a base and one acting as an acid.

1

2

#### Question 18 (4 marks)

Ozone and oxygen are allotropes. Account for the difference in their properties on the basis of their molecular structure and bonding.

4

#### Question 19 (6 marks)

You are given a sample of water to analyse for its drinking quality. List three tests that need to be carried out to determine the drinking quality of the sample and explain the importance of each test for this purpose.

6

#### Question 20 (4 marks)

Outline and describe the role of a particular chemist employed in a named industry.

4

#### Question 21 (6 marks)

Marks

Chemical reactions in industry need to be monitored continuously so that yields are maximised and costs are kept low.

6

Discuss this statement with reference to the Haber process.

#### Question 22 (7 marks)

Oxides of sulfur are readily released into the atmosphere with detrimental effects.

- (a) (i) Identify natural and industrial sources of the oxides of sulfur.

4

- (ii) Use equations to show how the two common oxides of sulfur are formed.

- (b) Explain why the oxides of sulfur are causing concern when released into the atmosphere. Use equations to support your explanation.

3

#### Question 23 (2 marks)

Outline the differences between the alkanol and alkanolic acid functional groups in carbon compounds.

2

#### Question 24 (8 marks)

- (a) Outline the differences between the definition of acids and bases proposed by Lewis and those of Brønsted and Lowry.

4

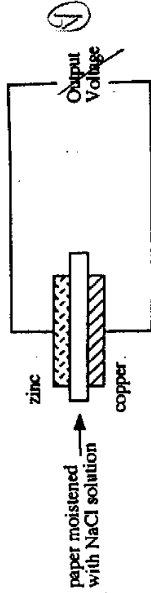
- (b) Explain how both theories in part (a) increased our understanding of acids and bases.

4

#### Question 25 (4 marks)

Discuss the advantages and disadvantages of using ethanol as an alternative fuel.

4

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| <p><b>Question 26 (4 marks)</b></p> <p>Ethene is an important industrial chemical.</p> <p>(a) Ethene is obtained from oil as a by-product of catalytic cracking. Name a commonly used catalyst in this industrial process and state if it is classed as a homogeneous or heterogeneous catalyst.</p> <p>(b) Ethene can also be obtained from ethanol.</p> <p>(i) Write the equation for the production of ethene from ethanol.</p> <p>(ii) Identify the catalyst used in this reaction and describe how it works.</p>                                                                                                            | <p>Marks</p> <p>2</p> <p>2</p> | <p><b>Question 29 (2 marks)</b></p> <p>Describe using an equation how and where a named transuranic element can be produced.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <p>Marks</p> <p>2</p>                        |
| <p><b>Question 27 (6 marks)</b></p> <p>The radioactive isotope sodium-24 is a <math>\beta^-</math>- and <math>\gamma</math>-emitter</p> <p>(a) Write the equation for the decay of sodium-24.</p> <p>(b) Describe two types of instruments or processes that can be used to detect radiation.</p> <p>(c) (i) What feature(s) would sodium-24 exhibit that make it suitable as a leak detector in water and oil pipelines?</p> <p>(ii) Describe how sodium-24 can be used as a leak detector in water or oil pipelines.</p>                                                                                                       | <p>1</p> <p>2</p> <p>3</p>     | <p><b>Question 30 (11 marks)</b></p> <p>In 1794, Alessandro Volta constructed the first electrochemical cell. He used a zinc plate and a copper plate separated by a sheet of paper moistened with sodium chloride solution.</p>  <p>Volta observed that the zinc plate was gradually eaten away as the cell operated, but the copper was not. Small bubbles of gas (which proved to be hydrogen) formed continuously at the surface of the copper nearer the paper.</p> <p>(a) (i) Write a balanced half-equation to explain the change in the zinc plate.</p> <p>(ii) Write a balanced half-equation to explain the formation of bubbles on the copper plate.</p> <p>(iii) Write the fully balanced equation for the reaction.</p> <p>(iv) Assuming <i>standard conditions</i>, calculate the voltage of the cell.</p> <p>(v) Are the conditions, as described above, <i>standard conditions</i>? Explain.</p> <p>(vi) Describe the direction of electron flow in the cell.</p> <p>(b) Which metal would be the anode of the cell? Explain.</p> <p>(c) The cell did not operate when the paper was moistened with pure water. Why?</p> <p>(d) Explain why this cell is classed as a galvanic cell and not an electrolytic cell.</p> <p>(e) Discuss how this cell has impacted (benefitted) on modern society.</p> | <p>6</p> <p>1</p> <p>1</p> <p>1</p> <p>2</p> |
| <p><b>Question 28 (6 marks)</b></p> <p>Aminoethane, <math>C_2H_5NH_2</math> is soluble in water. It can act as either an acid or base (at the <math>NH_2</math> end).</p> <p>(a) (i) What is the name given to a species that can act as an acid or base?</p> <p>(ii) Using equations clearly show <math>C_2H_5NH_2</math> acting as an acid and then a base.</p> <p>(iii) Underline one conjugate acid-base pair in either of the equations above.</p> <p>(b) Describe a simple test that could be carried out in the school laboratory that would verify that <math>C_2H_5NH_2</math> acts as a <u>weak</u> base in water.</p> | <p>4</p> <p>2</p>              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                              |

**Section II – Option**

**Total marks (7)**

**Attempt Question 31**

**Allow about 15 minutes for this section**

Answer the question in a writing booklet. Extra Writing booklets are available.

Show all relevant working in questions involving calculations.

| Question 31 – Shipwrecks and Salvage (7 marks)                                |                                                                                                                                                                               |  | Marks |
|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-------|
| (a)                                                                           | Identify the two major sources (origins) of the minerals in oceans.                                                                                                           |  | 2     |
| (b)                                                                           | Identify each of the parts of the shorthand notation for the electrochemical cell:<br>$\text{Fe} \mid \text{Fe}^{2+} \parallel \text{Fe}^{3+}, \text{Fe}^{2+} \mid \text{Pt}$ |  | 5     |
| and calculate the voltage produced by the cell (assuming standard conditions) |                                                                                                                                                                               |  |       |

# CHEMISTRY DATA SHEET

Values of several numerical constants

$$6.022 \times 10^{23} \text{ mol}^{-1}$$

Avogadro's constant,  $N_A$

Volume of 1 mole ideal gas:

at 101.3 kPa (1.00 atm) and

at 273 K (0°C)

at 298 K (25°C)

Ionisation constant for water

at 298 K (25°C),  $K_w$

Specific heat capacity of water

Some useful formulae

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

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

Some standard potentials

|                                                    |                                                        |         |
|----------------------------------------------------|--------------------------------------------------------|---------|
| $\text{K}^+ + \text{e}^-$                          | $\text{K(s)}$                                          | -2.94 V |
| $\text{Ba}^{2+} + 2\text{e}^-$                     | $\text{Ba(s)}$                                         | -2.91 V |
| $\text{Ca}^{2+} + 2\text{e}^-$                     | $\text{Ca(s)}$                                         | -2.87 V |
| $\text{Na}^+ + \text{e}^-$                         | $\text{Na(s)}$                                         | -2.71 V |
| $\text{Mg}^{2+} + 2\text{e}^-$                     | $\text{Mg(s)}$                                         | -2.36 V |
| $\text{Al}^{3+} + 3\text{e}^-$                     | $\text{Al(s)}$                                         | -1.68 V |
| $\text{Mn}^{2+} + 2\text{e}^-$                     | $\text{Mn(s)}$                                         | -1.18 V |
| $\text{Zn}^{2+} + 2\text{e}^-$                     | $\text{Zn(s)}$                                         | -0.76 V |
| $\text{Fe}^{2+} + 2\text{e}^-$                     | $\text{Fe(s)}$                                         | -0.44 V |
| $\text{Ni}^{2+} + 2\text{e}^-$                     | $\text{Ni(s)}$                                         | -0.25 V |
| $\text{Sn}^{2+} + 2\text{e}^-$                     | $\text{Sn(s)}$                                         | -0.14 V |
| $\text{Pb}^{2+} + 2\text{e}^-$                     | $\text{Pb(s)}$                                         | -0.13 V |
| $\text{H}^+ + \text{e}^-$                          | $\text{H}^+(\text{aq})$                                | 0.00 V  |
| $\text{SO}_4^{2-} + 4\text{H}^+ + 2\text{e}^-$     | $\text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq})$ | 0.16 V  |
| $\text{Cu}^{2+} + 2\text{e}^-$                     | $\text{Cu(s)}$                                         | 0.34 V  |
| $\text{Fe}^{3+} + \text{e}^-$                      | $\text{Fe}^{3+}(\text{aq})$                            | 0.77 V  |
| $\text{Fe}^{2+} + 2\text{e}^-$                     | $\text{Fe(s)}$                                         | 0.63 V  |
| $\text{Ag}^+ + \text{e}^-$                         | $\text{Ag(s)}$                                         | 0.80 V  |
| $\text{Br}_2(\text{l}) + 2\text{e}^-$              | $\text{Br}_2(\text{l})$                                | 1.08 V  |
| $\text{I}_2(\text{s}) + 2\text{e}^-$               | $\text{I}_2(\text{s})$                                 | 1.10 V  |
| $\text{O}_2(\text{g}) + 4\text{H}^+ + 4\text{e}^-$ | $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq})$        | 1.23 V  |
| $\text{O}_2(\text{g}) + 2\text{H}^+ + 2\text{e}^-$ | $\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq})$        | 1.36 V  |
| $\text{Cl}_2(\text{g}) + 2\text{e}^-$              | $\text{Cl}_2(\text{g})$                                | 1.36 V  |
| $\text{Cl}_2(\text{aq}) + 2\text{e}^-$             | $\text{Cl}_2(\text{aq})$                               | 1.40 V  |
| $\text{MnO}_4^- + 8\text{H}^+ + 5\text{e}^-$       | $\text{Mn}^{2+} + 4\text{H}_2\text{O}$                 | 1.51 V  |
| $\text{F}_2(\text{g}) + 2\text{e}^-$               | $\text{F}^-(\text{aq})$                                | 2.89 V  |

Aylward and Findlay, SI Chemical Data (4th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

This sheet should be REMOVED for your convenience.

Where the atomic weights of Mp and Tc are given for the isotopes  $^{237}\text{Np}$  and  $^{232}\text{Th}$ , the relative atomic mass of the most common radioactive isotope is shown in brackets.

| Atomic Number | Symbol of element | Name of element | Atomic Weight | Relative Atomic Mass |
|---------------|-------------------|-----------------|---------------|----------------------|
| 1             | H                 | Hydrogen        | 1.008         |                      |
| 2             | He                | Helium          | 4.003         |                      |
| 3             | Li                | Lithium         | 6.941         |                      |
| 4             | Be                | Beryllium       | 9.012         |                      |
| 5             | B                 | Boron           | 10.81         |                      |
| 6             | C                 | Carbon          | 12.01         |                      |
| 7             | N                 | Nitrogen        | 14.01         |                      |
| 8             | O                 | Oxygen          | 16.00         |                      |
| 9             | F                 | Fluorine        | 19.00         |                      |
| 10            | Ne                | Neon            | 20.18         |                      |
| 11            | Na                | Sodium          | 22.99         |                      |
| 12            | Mg                | Magnesium       | 24.31         |                      |
| 13            | Al                | Aluminium       | 26.98         |                      |
| 14            | Si                | Silicon         | 28.09         |                      |
| 15            | P                 | Phosphorus      | 30.97         |                      |
| 16            | S                 | Sulphur         | 32.07         |                      |
| 17            | Cl                | Chlorine        | 35.45         |                      |
| 18            | Ar                | Argon           | 39.95         |                      |
| 19            | K                 | Potassium       | 39.10         |                      |
| 20            | Ca                | Calcium         | 40.08         |                      |
| 21            | Sc                | Scandium        | 44.96         |                      |
| 22            | Ti                | Titanium        | 47.87         |                      |
| 23            | V                 | Vanadium        | 50.94         |                      |
| 24            | Cr                | Chromium        | 52.00         |                      |
| 25            | Mn                | Manganese       | 54.94         |                      |
| 26            | Fe                | Iron            | 55.85         |                      |
| 27            | Co                | Cobalt          | 58.93         |                      |
| 28            | Ni                | Nickel          | 58.69         |                      |
| 29            | Cu                | Copper          | 63.55         |                      |
| 30            | Zn                | Zinc            | 65.39         |                      |
| 31            | Ga                | Gallium         | 69.72         |                      |
| 32            | Ge                | Germanium       | 72.61         |                      |
| 33            | As                | Arsenic         | 74.92         |                      |
| 34            | Se                | Selenium        | 78.96         |                      |
| 35            | Br                | Bromine         | 79.90         |                      |
| 36            | Kr                | Krypton         | 83.80         |                      |
| 37            | Rb                | Rubidium        | 85.47         |                      |
| 38            | Sr                | Strontium       | 87.62         |                      |
| 39            | Y                 | Yttrium         | 88.91         |                      |
| 40            | Zr                | Zirconium       | 91.22         |                      |
| 41            | Nb                | Niobium         | 92.91         |                      |
| 42            | Mo                | Molybdenum      | 95.94         |                      |
| 43            | Tc                | Technetium      | [98.91]       |                      |
| 44            | Ru                | Ruthenium       | 101.1         |                      |
| 45            | Rh                | Rhodium         | 102.9         |                      |
| 46            | Pd                | Palladium       | 106.4         |                      |
| 47            | Ag                | Silver          | 107.9         |                      |
| 48            | Cd                | Cadmium         | 112.4         |                      |
| 49            | In                | Indium          | 114.8         |                      |
| 50            | Sn                | Tin             | 118.7         |                      |
| 51            | Sb                | Antimony        | 121.8         |                      |
| 52            | Te                | Tellurium       | 127.6         |                      |
| 53            | I                 | Iodine          | 126.9         |                      |
| 54            | Xe                | Xenon           | 131.3         |                      |
| 55            | Cs                | Cesium          | 132.9         |                      |
| 56            | Ba                | Barium          | 137.3         |                      |
| 57            | La                | Lanthanum       | 138.9         |                      |
| 58            | Ce                | Cerium          | 140.1         |                      |
| 59            | Pr                | Praseodymium    | 140.9         |                      |
| 60            | Nd                | Neodymium       | 144.2         |                      |
| 61            | Pm                | Promethium      | [146.9]       |                      |
| 62            | Sm                | Samarium        | 150.4         |                      |
| 63            | Eu                | Europium        | 152.0         |                      |
| 64            | Gd                | Gadolinium      | 157.3         |                      |
| 65            | Tb                | Terbium         | 158.9         |                      |
| 66            | Dy                | Dysprosium      | 162.5         |                      |
| 67            | Ho                | Holmium         | 164.9         |                      |
| 68            | Er                | Erbium          | 167.3         |                      |
| 69            | Tm                | Thulium         | 168.9         |                      |
| 70            | Yb                | Ytterbium       | 173.0         |                      |
| 71            | Lu                | Lutetium        | 175.0         |                      |
| 72            | Hf                | Hafnium         | 178.5         |                      |
| 73            | Ta                | Tantalum        | 180.9         |                      |
| 74            | W                 | Tungsten        | 183.8         |                      |
| 75            | Re                | Rhenium         | 186.2         |                      |
| 76            | Os                | Osmium          | 190.2         |                      |
| 77            | Ir                | Iridium         | 192.2         |                      |
| 78            | Pt                | Platinum        | 195.1         |                      |
| 79            | Au                | Gold            | 197.0         |                      |
| 80            | Hg                | Mercury         | 200.6         |                      |
| 81            | Tl                | Thallium        | 204.4         |                      |
| 82            | Pb                | Lead            | 207.2         |                      |
| 83            | Bi                | Bismuth         | 208.98        |                      |
| 84            | Po                | Polonium        | [209]         |                      |
| 85            | At                | Astatine        | [210]         |                      |
| 86            | Rn                | Radon           | [222]         |                      |
| 87            | Fr                | Francium        | [223]         |                      |
| 88            | Ra                | Radium          | [226]         |                      |
| 89            | Ac                | Actinium        | [227]         |                      |
| 90            | Th                | Thorium         | 232.0         |                      |
| 91            | Pa                | Protactinium    | 231.0         |                      |
| 92            | U                 | Uranium         | 238.0         |                      |
| 93            | Np                | Neptunium       | [237.0]       |                      |
| 94            | Pu                | Plutonium       | [239.1]       |                      |
| 95            | Am                | Americium       | [241.1]       |                      |
| 96            | Cm                | Curium          | [244.1]       |                      |
| 97            | Bk                | Berkelium       | [247.1]       |                      |
| 98            | Cf                | Californium     | [251.1]       |                      |
| 99            | Es                | Einsteinium     | [252.1]       |                      |
| 100           | Fm                | Fermium         | [257.1]       |                      |
| 101           | Md                | Mendelevium     | [258.1]       |                      |
| 102           | No                | Nobelium        | [259.1]       |                      |
| 103           | Lr                | Lutetium        | [262.1]       |                      |