Student Number: ………………………..

2006

Term 1 Examination

HSC CHEMISTRY

General Instructions

- Reading time - 5 minutes
- Working time - 2 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board approved calculators may be used
- A data sheet and periodic table are provided at the back of this paper
- Write your student number at the top of every page.

Total marks - 65

This exam has two parts, Part A and Part B

Section I – 53 marks
Part A (10 marks)
- Attempt Questions 1-10
- Allow about 20 minutes for this section

Part B (43 marks)
- Attempt Questions 11- 18
- Allow about 70 minutes

Section II - 12 marks
Option
- Attempt Question 19
- Allow about 30 minutes for this section

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Student Number: ………………………..

Section 1
53 marks

Part A

Total marks 10
Attempt questions 1-10
Allow about 20 minutes for this part.

Use the Multiple-choice Answer Sheet provided.

Answer the questions by selecting the alternative that best answers the question. Indicate your choice by filling in the appropriate place on the Answer sheet, as shown below, where **A** has been selected as the best alternative,

If you make a mistake, indicate your choice by labelling the correct alternative, as shown below where, the original choice **A** was a mistake, and **C** is now selected as being the correct answer.

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1. Which of the following pairs would form a buffer solution?

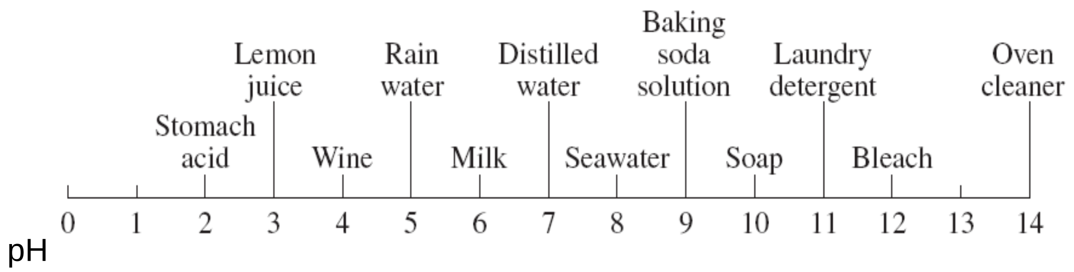
(A) $HCl_{(aq)}$ / $Cl^-_{(aq)}$

(B) $H_2PO_4^-{}_{(aq)}$ / $PO_4^{3-}{}_{(aq)}$

(C) $H_2SO_4{}_{(aq)}$ / $HSO_4^-{}_{(aq)}$

(D) $CH_3COOH_{(aq)}$ / $CH_3COO^-{}_{(aq)}$

2. The figure shows the pH values of some substances.



Based on the pH values shown in the figure, in which of the following is the concentration of hydrogen ions correct?

(A) It is twice as great in milk as that in lemon juice

(B) It is 1 000 000 times greater in soap than in wine

(C) It is three times greater in wine than in bleach solution

(D) It is 1 000 times greater in distilled water than in soap

3. The table shows the colours of three indicators at different hydrogen ion concentrations.

[HCl] $molL^{-1}$	10^{-2}	10^{-4}	10^{-6}
Methyl Orange	red	orange	yellow
Bromothymol Blue	yellow	yellow	green
Phenol Red	yellow	red	red

What is the pH of a solution that showed the following indicator colours?

Methyl Orange	Yellow
Bromothymol Blue	Green
Phenol Red	Red

(A) 2

(B) 4

(C) 6

(D) 8

4 One mole of which of the following acids will require three moles of sodium hydroxide to achieve complete neutralisation?

(A) hydrochloric acid

(B) citric acid

(C) sulphuric acid

(D) ethanoic acid

5 The following equilibria occur in a bottle of carbonated soft drink:

$CO_{2(g)} \leftrightarrows CO_{2\,(aq)}$ + energy

$CO_{2\,(aq)} + H_2O_{(l)} \leftrightarrows H_2CO_{3(aq)}$

$H_2CO_{3(aq)} + 2\,H_2O_{(l)} \leftrightarrows 2\,H_3O^+_{(aq)} + CO_3^{2-}{}_{(aq)}$

Which one of the following will favour the release of carbon dioxide from the soft drink?

(A) putting a lid on the bottle

(B) decreasing the temperature of the soft drink

(C) increasing the pH of the soft drink

(D) adding a small amount of vinegar to the soft drink

6 10 mL of a 0.05 $molL^{-1}$ solution of sulphuric acid was diluted by making up to 1000 mL with distilled water. What was the pH of the resulting solution?

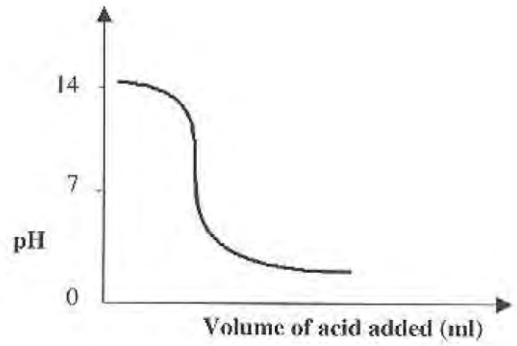
(A) 3.0

(B) 2.0

(C) 4.0

(D) 3.3

7 A student performed a titration with a strong base and an acid. He used computer based technology and the following graph was produced.



From the information in the graph it can be deduced that:

(A) the acid was a weak acid and the end point was at pH 8

(B) the acid was a strong acid and the end point was at pH 8

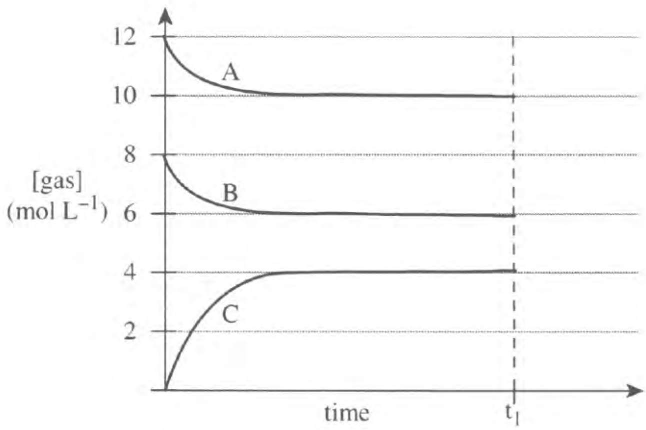
(C) the acid was a weak acid and the end point was at pH 2.5

(D) the acid was a strong acid and the end point was at pH 11

8 Which of the following correctly identifies the amphiprotic species with both its conjugate acid and its conjugate base?

	Conjugate acid	*Amphiprotic species*	*Conjugate base*
(A)	HCO_3^-	H_2CO_3	CO_3^{2-}
(B)	NH_4^+	NH_3	NH_2^-
(C)	OH^-	H_2O	H_3O^+
(D)	H_2SO_4	SO_4^{2-}	HSO_4^-

9 It is known that gases A and B reach equilibrium as they react together to form gas C. The variation in concentration of these gases was monitored and graphed as illustrated below.



By applying Le Chatelier's Principle, it can be predicted that at time t_1 the yield of the forward reaction will

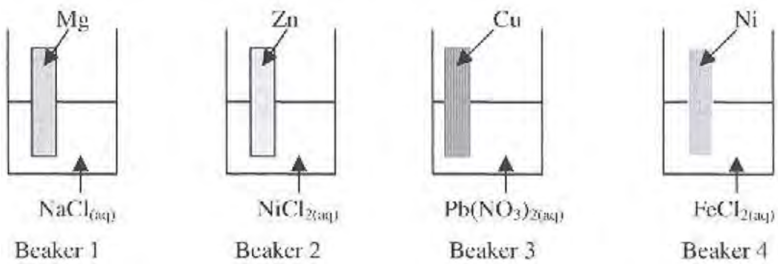
(A) increase if pressure is increased.

(B) decrease if pressure is increased.

(C) decrease if pressure is decreased.

(D) not be affected by a change in pressure.

10 In which one of the following beakers will a displacement reaction occur?



(A) Beaker 1

(B) Beaker 2

(C) Beaker 3

(D) Beaker 4

Student Number: ………………………..

Section 1 (continued)

Part B – 43 marks
Attempt Questions 11-19
Allow about 1 hour and 10 minutes for this part

Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 11 (5 marks)

During your practical work, you have performed a first-hand investigation to prepare and test a natural acid/base indicator.

(a) Describe the procedure you used to test this indicator and explain how this indicator can distinguish between an acid and a base. **3**

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(b) Identify an everyday situation in which an indicator is used and explain why it is necessary to use the indicator. **2**

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Question 12 (4 marks)
Vinegar is an aqueous solution of acetic (ethanoic) acid, a weak acid.

(a) Apart from its taste, explain why acids such as vinegar are often used as food additives. **2**

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(b) Explain why such a solution would have a higher pH than hydrochloric acid solution of the same concentration. **2**

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Question 13 (6 marks)

Different theories of acids and bases were developed by Lavoisier, Davy, Arrhenius and Bronsted-Lowry. Sulphuric acid, H_2SO_4, was classified as an acid by all of these scientists.

Explain how each of their theories predict that H_2SO_4 is an acid. Support your answer by using equations where appropriate. **6**

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Question 14 (5 marks)

Low sulphur diesel fuels used in coal mining must have a low sulphur content of less than 0.05% by mass.

(a) Calculate the volume of sulphur dioxide at 25°C and 100 kPa produced by burning 1.0 kg of low (0.05%) sulphur diesel **2**

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(b) Discuss the impact on the environment of using high sulphur fuels. **3**

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Question 15 (6 marks)

A 500 mL bottle of concentrated sulphuric acid ($18 molL^{-1}$) was dropped in a laboratory accident. Solid sodium hydrogen carbonate ($NaHCO_3$) was used to neutralise the spilled acid.

(a) Justify the choice of the solid sodium hydrogen carbonate to clean up the spill. Include relevant equation(s). **4**

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(b) Calculate the minimum mass of sodium hydrogen carbonate to neutralise the spilled acid completely. **2**

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Question 16 (5 marks)

An antacid tablet is known to contain calcium carbonate ($CaCO_3$). To determine the mass of calcium carbonate in the tablet, the following procedure was used.

- The tablet was crushed and then placed in a beaker.
- A pipette was used to add 25.0 mL of 0.60 $molL^{-1}$ hydrochloric acid to the crushed tablet in the beaker.
- Once the reaction between the calcium carbonate and hydrochloric acid had stopped, the phenolphthalein indicator was added to the reaction mixture.
- A Teflon-coated burette was then used to add 0.100 $molL^{-1}$ sodium hydroxide to the beaker to neutralise the excess hydrochloric acid.
- The phenolphthalein changed from colourless to pink after 14.2 mL of sodium hydroxide solution had been added.

(a) Write a balanced chemical equation for the reaction that occurred between the calcium carbonate in the tablet and the hydrochloric acid. **1**

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(b) How many moles of hydrochloric acid were added to the tablet? **1**

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(c) Calculate the mass of calcium carbonate in the original antacid tablet. **3**

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Question 17 (5 marks)

During your practical work you performed a first-hand investigation to prepare an ester.

(a) Identify the ester and write the equation for the reaction to prepare the ester. **1**

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(b) Justify the reaction conditions you used in preparing the ester. **2**

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(c) Identify safety issues for this experiment and describe measures taken to address the issues. **2**

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Question 18 (7 marks)

Consider the following electrochemical cell:

$X_{(s)} \mid X^{2+}_{(aq)} \mid\mid Y^{+}_{(aq)} \mid Y_{(s)}$

(a) Draw a labelled diagram of this cell, clearly indicating the direction of electron and ion flow. **3**

(b) The EMF of the cell under standard conditions is 0.96V. Given that the reduction potential for $Y^{+}_{(aq)} + e^{-} \leftrightarrows Y_{(s)}$ is 0.52V, write the oxidation half-equation for the cell, including its voltage. **2**

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(c) The cell will eventually reach of state of equilibrium. Use Le Chatelier's Principle to justify the prediction that if the concentration of Y^{+} is increased, the voltage will also increase. **2**

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Section II

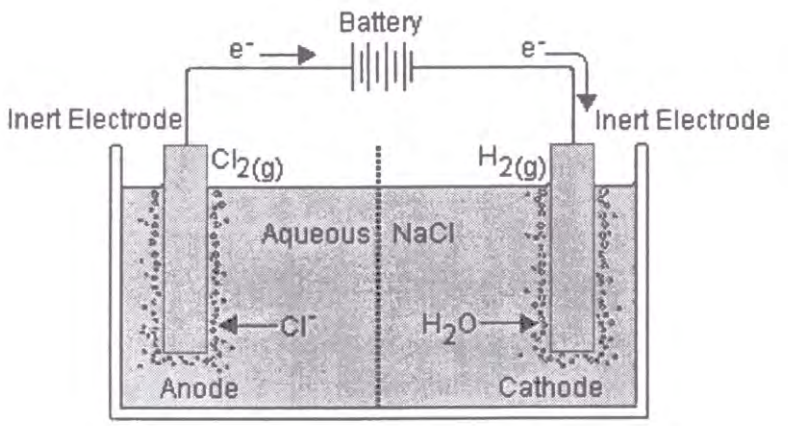
12 marks
Attempt all parts of Question 19
Allow 30 minutes for this section

Answer the question in a SEPARATE writing booklet.

Show all relevant working in questions involving calculations.

Question 19 – Shipwrecks, Corrosion and Conservation

(a) Refer to the diagram below



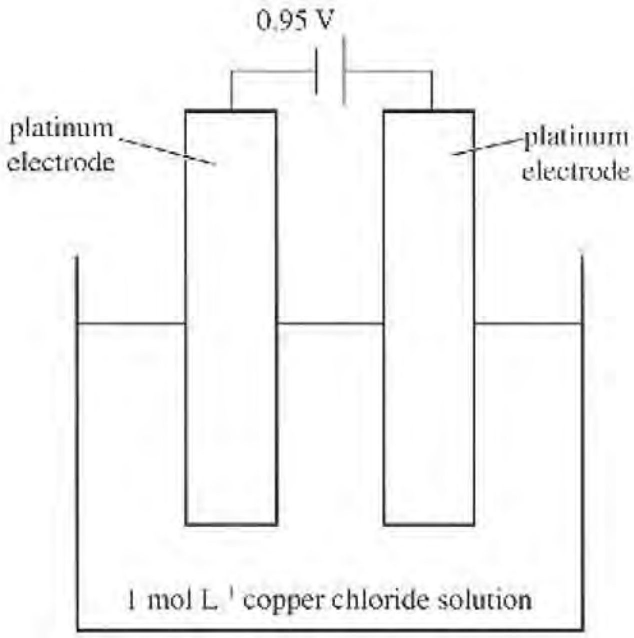
Using the information from the above diagram, indicate using equations ONE possible anode AND ONE possible cathode reaction that may occur at these electrodes. **1**

(b) Describe how the nature of the electrode affects the electrolytic reaction. **2**

(c) Sodium, iron and silver are all metals. Arrange them in order of increasing reactivity and justify your answer using the table of Standard Reduction Potentials. **2**

Question 19 continued…

(d) In her study of electrolytic cells, a student came across the following diagram. **7**



Based on this diagram, the student made the following predictions:

- The voltage was insufficient to form copper and chlorine by electrolysis of the solution
- The mass of the anode would increase as copper formed on it.
- A gas would form at the other electrode
- The pH of the electrolyte will not change.

Assess each of these predictions. Support your assessment with appropriate data and equations where possible to identify products. If the student's prediction is incorrect, provide an alternate prediction.

Student Number: ………………………..

DATA SHEET

Avogadro constant, N_A .... 6.022×10^{23} mol^{-1}
Volume of 1 mole ideal gas: at 100 kPa and
at 0°C (273.15 K) .... 22.71 L
at 25°C (298.15 K) .... 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 J kg^{-1} K^{-1}

Some useful formulae

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

Some 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
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_2(aq) + 2H_2O$	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
$\frac{1}{2}O_2(g) + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2}Cl_2(g) + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2}Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2}H_2O$	1.36 V
$\frac{1}{2}Cl_2(aq) + e^-$	$\rightleftharpoons$	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

Aylward and Findlay, *SI Chemical Data* (5th Edition) is the principal source of data for this examination paper. Some data may have been modified for examination purposes.

Student Number: ………………………..

PERIODIC TABLE OF THE ELEMENTS

KEY

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