VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2002

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter
Words									

CHEMISTRY

Written examination 1

Tuesday 11 June 2002

Reading time: 11.45 am to 12.00 noon (15 minutes)
Writing time: 12.00 noon to 1.30 pm (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*	*Suggested times (minutes)*
A	20	20	20	27
B	7	7	52	63
			Total 72	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 18 pages, with a detachable data sheet in the centrefold.
- Answer sheet for multiple-choice questions.

Instructions
- Detach the data sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

SECTION A

Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.

A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No mark will be given if more than one answer is completed for any question.

Question 1

1 g of each of the following substances is dissolved in 1 L of water.

In which one would the pH of the resultant solution be closest to 7?

A. H_2SO_4
B. NH_3
C. $NaHSO_4$
D. NaCl

Question 2

Some carbon dioxide is to be generated by reacting 50 g of calcium carbonate with a solution of hydrochloric acid.

Which of the following actions is **least** likely to lead to an increase in the rate of formation of carbon dioxide?

A. grinding the calcium carbonate to a fine powder
B. raising the temperature
C. raising the atmospheric pressure
D. raising the concentration of hydrochloric acid

Question 3

In which one of the following would the position of the equilibrium **not** be affected by a volume change at constant temperature?

A. $2CO(g) + O_2(g) \rightleftharpoons 2CO_2(g)$
B. $C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$
C. $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
D. $CO(g) + H_2O(g) \rightleftharpoons H_2(g) + CO_2(g)$

Question 4

When concentrated sulfuric acid is poured onto solid sodium bromide, the liquid turns brown as bromine is produced.

In this reaction the sulfuric acid is acting as

A. an oxidant.
B. a reductant.
C. a dehydrating agent.
D. a strong acid.

Question 5

The best description of the effect of a catalyst on a chemical reaction is that it

A. lowers the activation energy of the forward reaction without changing the activation energy of the reverse reaction.

B. lowers the activation energy of the forward reaction and raises the activation energy of the reverse reaction.

C. lowers the activation energy of both forward and reverse reactions by the same amount.

D. lowers the activation energy of the reverse reaction without changing the activation energy of the forward reaction.

Question 6

0.010 mol of chloral hydrate, $CCl_3CH(OH)_2$, is dissolved in a pure organic solvent. The resulting solution is made up to one litre exactly. In this solvent, the chloral hydrate dissociates to chloral, CCl_3CHO, and water. The chemical reaction for the process is

$$CCl_3CH(OH)_2\text{(in solution)} \rightleftharpoons CCl_3CHO\text{(in solution)} + H_2O\text{(in solution)}$$

When the reaction has reached equilibrium the concentration of water in the solution is measured to be 0.0020 M. The equilibrium constant for the reaction at this temperature would be

A. 4.0×10^{-4}

B. 5.0×10^{-4}

C. 0.20

D. 0.25

Question 7

Water and chlorine, each at 1 atm pressure, are placed in a closed container at 375 K. The following reaction occurs.

$$2H_2O(g) + 2Cl_2(g) \rightleftharpoons 4HCl(g) + O_2(g), \quad K = 5 \times 10^{-4} \text{ at } 375 \text{ K}$$

Which one of the following will be correct at equilibrium at this temperature?

A. $2[O_2] > [Cl_2]$

B. $2[Cl_2] > [HCl]$

C. $2[HCl] = [Cl_2]$

D. $[O_2] = 4[HCl]$

Question 8

Given the equilibrium,

$$A_2(g) + 4C(g) \rightleftharpoons 2AC_2(g), \quad K_1 = 4.8$$

It follows that, for the reaction,

$$AC_2(g) \rightleftharpoons \frac{1}{2}A_2(g) + 2C(g), \quad K_2 = \mathbf{X}$$

X would be

A. $\frac{1}{4.8}$

B. 2.4

C. $\frac{1}{2.4}$

D. $\frac{1}{\sqrt{4.8}}$

Question 9

An aqueous solution of copper sulfate is a clear blue colour. The concentration of this solution is to be measured using UV-visible spectroscopy.

An aqueous copper sulfate solution will

A. absorb mainly red light and therefore allow red light to pass through the solution.

B. absorb mainly red light and therefore allow blue light to pass through the solution.

C. absorb mainly blue light and therefore allow red light to pass through the solution.

D. absorb mainly blue light and therefore allow blue light to pass through the solution.

Question 10

5.00 g of nitrogen is completely converted into an oxide of nitrogen. The mass of the oxide formed is 19.3 g.

The empirical formula of the oxide would be

A. NO

B. N_2O_3

C. NO_2

D. N_2O_5

Question 11

The transition metal vanadium exists in a range of different oxidation states. Two vanadium species are VO^{2+} and VO_4^{3-}.

The oxidation states of vanadium in these two species are, respectively,

A. +4 and +5

B. +4 and +8

C. +6 and +5

D. +6 and +8

Question 12

100 mL of an 0.0100 M aqueous solution of calcium hydroxide will absorb carbon dioxide according to the equation

$$Ca(OH)_2(aq) + 2CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$$

The maximum volume, in mL, at STP of CO_2 that could be absorbed by the solution is

A. 22.4

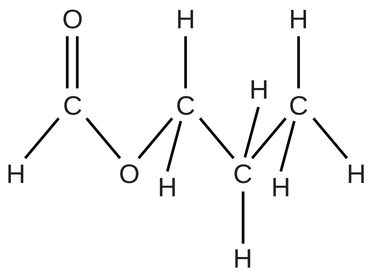
B. 44.8

C. 224

D. 448

Question 13

A compound associated with the smell or flavour of raspberries has the structure



To synthesise this compound in the laboratory you would react

A. methanol and propanoic acid.

B. methanol and butanoic acid.

C. 1-propanol and methanoic acid.

D. 1-butanol and methanoic acid.

Question 14

In pure water at 5°C the hydroxide ion concentration is measured to be 4.0×10^{-8} M.

The K_w and pH of pure water at this temperature will be, respectively,

A. 1.0×10^{-14} and 7.0

B. 1.0×10^{-14} and 6.6

C. 1.6×10^{-15} and 7.0

D. 1.6×10^{-15} and 7.4

Question 15

When two mole of an organic compound is burnt in oxygen, eight mole of carbon dioxide gas is formed. In a second test, when a few drops of bromine are added to the compound and shaken, the bromine rapidly decolourises.

The formula of the compound could be

A. C_4H_8

B. C_4H_{10}

C. C_8H_{16}

D. C_8H_{18}

Question 16

Sulfur compounds are often present in crude oil.

If a sample of crude oil containing 1% sulfur was burnt in air, which of the following compounds would be produced in the **smallest** amount in the flame?

A. SO_3

B. SO_2

C. H_2O

D. CO_2

Question 17

A large polyethene molecule is found to have a relative molecular mass of 4.0×10^4.

The number of carbon atoms in this molecule would be closest to

A. 1500

B. 2900

C. 3300

D. 1.8×10^{27}

Question 18

Concentrated H_2SO_4 is often used in the laboratory as a dehydrating agent for gases.

For which one of the following gases would this method **not** be suitable?

A. O_2

B. N_2

C. NH_3

D. CO_2

Questions 19 and 20 refer to the following equilibrium.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \qquad \Delta H = -197 \text{ kJ mol}^{-1}; \quad K = 4.5 \text{ at } 600 \text{ K}$$

In a particular exercise, a mixture of 4.0 mol of sulfur dioxide and 1.0 mol of oxygen is allowed to reach equilibrium at 600 K.

Question 19

The amount of sulfur trioxide present at equilibrium would be

A. 5 mol

B. 4 mol

C. 2 mol

D. less than 2 mol

Question 20

In a second exercise, the same initial amounts of reactants are mixed at 600 K in a well-insulated container of the same size.

In this case, the amount of sulfur trioxide present when the mixture reaches equilibrium would be

A. equal to the amount produced in the previous exercise.

B. less than the amount produced in the previous exercise.

C. more than the amount produced in the previous exercise.

D. impossible to predict from the information given.

END OF SECTION A

SECTION B

Instructions for Section B

Answer all questions in the spaces provided.

To obtain full marks for your responses you should

- give simplified answers with an appropriate number of significant figures to all numerical questions; unsimplified answers will not be given full marks.
- show all working in your answers to numerical questions. No credit will be given for an incorrect answer unless it is accompanied by details of the working.
- make sure chemical equations are balanced and that the formulas for individual substances include an indication of state; for example, $H_2(g)$; $NaCl(s)$.

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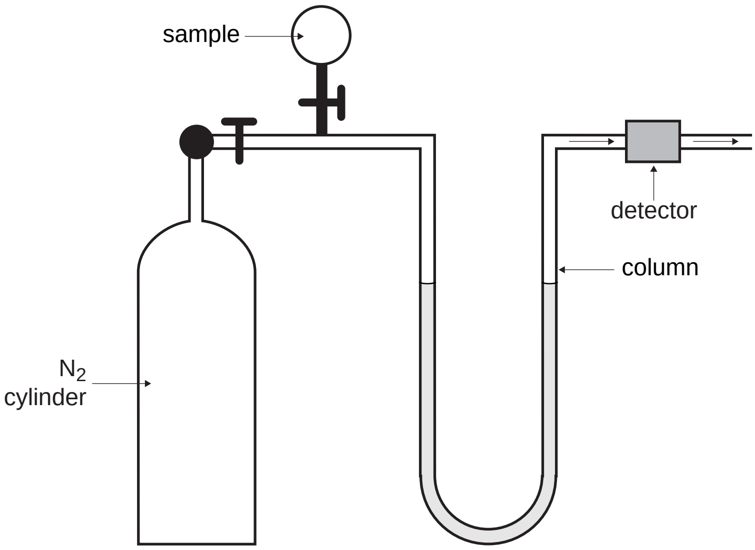
Question 1

The diagram below represents a gas chromatograph.



a. Clearly identify, on the diagram, the mobile and stationary phases in the gas chromatograph shown and explain how gas chromatography is able to separate the components of a gaseous mixture.

4 marks

b. A pure substance was suspected of being the high molecular weight anabolic steroid Stanozolol. A sample of this substance was dissolved in a suitable pure solvent and injected into a gas chromatograph. How many peaks would you expect to see in the resulting chromatogram? Justify your result.

2 marks

c. If a sample of pure Stanozolol were available, how could it be used in the gas chromatograph to confirm the identity of the suspect sample?

1 mark

Total 7 marks

Question 2

Gaseous propane reacts with chlorine in the presence of ultraviolet light.

a. Name the type of reaction that occurs.

1 mark

b. What is the function of the light?

1 mark

c. Other than various chlorinated hydrocarbons, what other compound is formed in this reaction?

1 mark

d. One of the possible products has the chemical formula C_3H_7Cl. Draw the structural formulas of **all** the possible isomers of C_3H_7Cl and give the name of **one** of them.

3 marks

Total 6 marks

Question 3

Boric acid (H_3BO_3) is a weak acid. Its conjugate base, the borate ion, exists in water as $B(OH)_4^-$. A solution of pure sodium borate, $NaB(OH)_4$, is prepared in water at 25ºC. The borate ion dissociates according to the equation

$$B(OH)_4^-(aq) \rightleftharpoons OH^-(aq) + H_3BO_3(aq)$$

a. Give an expression for the equilibrium constant for the reaction above.

1 mark

b. At equilibrium in a particular solution of $NaB(OH)_4$, the concentration of $B(OH)_4^-$ is exactly 0.100 M and the pH is 11.11

i. Calculate the hydrogen ion and hydroxide ion concentrations in the solution.

ii. Hence give the H_3BO_3 concentration in the solution.

4 marks

c. The equilibrium constant for the dissociation of boric acid is given by

$$K_a = \frac{[H^+][B(OH)_4^-]}{[H_3BO_3]}$$

Use the data from part **b.** to calculate the value of the K_a of boric acid.

1 mark

Total 6 marks

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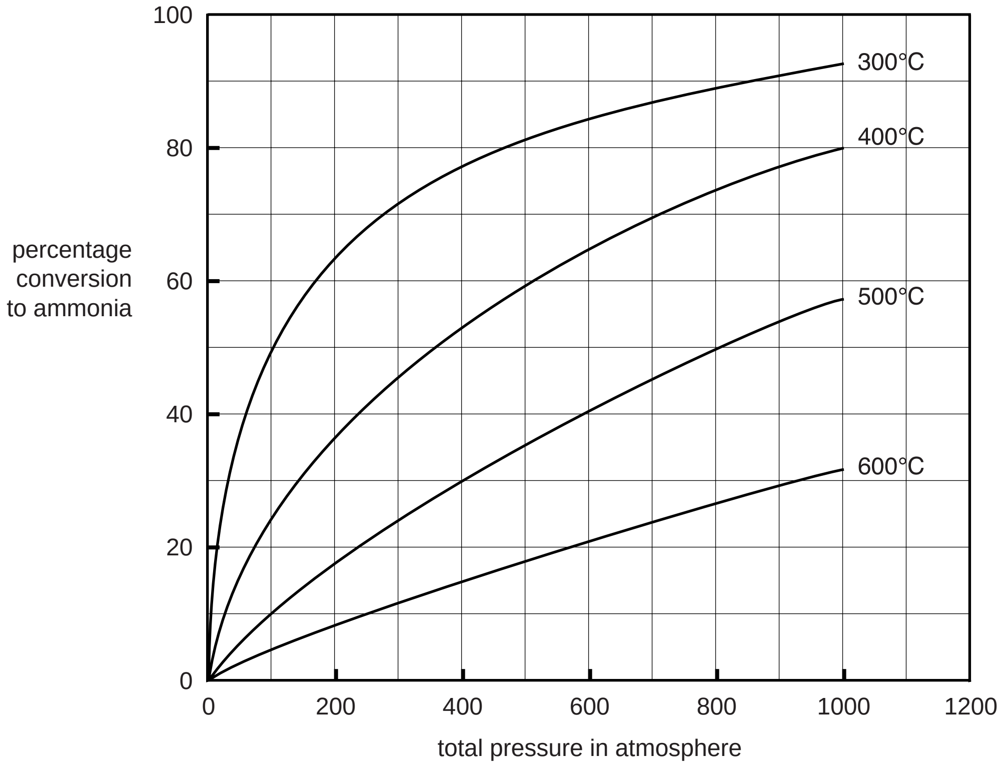
Question 4

Ammonia is prepared industrially from hydrogen and nitrogen in the presence of a suitable catalyst according to the equation

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The graph below shows the variation of the equilibrium yield of ammonia with pressure at different temperatures.



a. A particular industrial plant uses a pressure of 300 atm and a temperature of 500ºC. From the graph, determine the percentage yield of ammonia under these conditions.

1 mark

b. State Le Chatelier's principle.

2 marks

c. Deduce from the graph whether the production of ammonia from hydrogen and nitrogen is an exothermic or an endothermic reaction. Explain your reasoning.

2 marks

d. Temperatures less than 400°C are not used for this industrial reaction even though such temperatures give a greater equilibrium yield of ammonia. Give a possible reason why this is so.

1 mark

Total 6 marks

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Question 5

Esters are common components of artficial flavours. An ester, known to contain only the elements carbon, hydrogen and oxygen, was isolated and its composition analysed.

a. To determine the empirical formula of the ester, 1.02 g of the ester was burnt completely in excess oxygen. The only products formed were 2.20 g of carbon dioxide and 0.90 g of water vapour.

Calculate the

i. mass of carbon in 1.02 g of the compound.

ii. mass of hydrogen in 1.02 g of the compound.

iii. mass of oxygen in 1.02 g of the compound.

iv. empirical formula of the compound.

2 + 2 + 1 + 2 = 7 marks

b. Another sample of the compound was used to determine its molar mass. It was found that 51.0 g of the vaporised compound occupied the same volume as 16.0 g of oxygen gas at the same temperature and pressure.

Calculate the molar mass of the compound in g mol^{-1}.

2 marks

c. Using your answers to parts **a.** and **b.**, determine the molecular formula of the compound.

1 mark

d. Given that the compound is an ester, give a possible structural formula for the compound.

1 mark

Total 11 marks

Question 6

Some students were set the task of determining the concentration of acetic acid in a particular brand of vinegar. An outline of the method they used is given below.

1. A burette is filled with a standard solution of sodium hydroxide.
2. The vinegar is diluted by a factor of 10 in a volumetric flask. A pipette is used to transfer 20.00 mL of diluted vinegar to a conical flask and a few drops of phenolphthalein indicator is added.
3. The diluted vinegar is titrated with the base. Titrations are repeated until three concordant results are obtained.

The equation for the reaction is

$$NaOH(aq) + CH_3COOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

a. The volumetric flask, the burette, the pipette and the conical flask are all rinsed before they are used. Indicate which solution should be used to finally rinse each of these pieces of glassware by ticking your responses in the appropriate boxes below.

glassware used	rinse with water	rinse with diluted vinegar solution	rinse with NaOH solution
volumetric flask			
burette			
20.00 mL pipette			
conical flask			

4 marks

b. Why is the vinegar diluted before titrating?

1 mark

c. Explain why titrations are repeated until three concordant results are obtained.

1 mark

d. One student's results are given below. The data shown in the student's laboratory book was

concentration of NaOH(aq)	=	0.11 M
volume of undiluted vinegar	=	10.00 mL
total volume of diluted vinegar	=	100.00 mL
volume of diluted vinegar used in each titration	=	20.00 mL
average titre of NaOH	=	15.35 mL

Based on these results, calculate the concentration, in mol L^{-1}, of acetic acid in the undiluted vinegar solution. Be careful to use the correct number of significant figures in your answer.

4 marks

Total 10 marks

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Question 7

Petrol and ethene are both obtained from crude oil.

a. Name the process by which petrol is obtained from crude oil.

1 mark

b. **i.** Name the process by which ethene is obtained from the hydrocarbons extracted from crude oil.

ii. Write a chemical equation for the production of ethene from this process, using octane, C_8H_{18}, as the hydrocarbon.

2 marks

c. A chemistry book describes the properties of ethene as being

- unsaturated
- a flammable gas
- able to participate in addition reactions

i. What is meant by unsaturated?

ii. Write a balanced equation to show the burning of ethene in a large excess of air.

iii. Write a chemical equation to show ethene undergoing an addition reaction.

3 marks

Total 6 marks

END OF QUESTION AND ANSWER BOOK

CHEMISTRY

Written examination 1

DATA SHEET

Directions to students

Detach this data sheet during reading time.

This data sheet is provided for your reference.

Physical constants

F = 96 500 C mol^{-1}

R = 8.31 J K^{-1} mol^{-1}

1 atm = 101 325 Pa = 760 mmHg

0°C = 273 K

Molar volume at STP = 22.4 L mol^{-1}

Avogadro constant = 6.02 × 10^{23} mol^{-1}

Ideal gas equation

$pV = nRT$

The electrochemical series

	$E°$ in volt
$F_2(g) + 2e^- \rightarrow 2F^-(aq)$	+2.87
$H_2O_2(aq) + 2H^+(aq) + 2e^- \rightarrow 2H_2O(l)$	+1.77
$Au^+(aq) + e^- \rightarrow Au(s)$	+1.68
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$	+1.36
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(1)$	+1.23
$Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$	+1.09
$Ag^+(aq) + e^- \rightarrow Ag(s)$	+0.80
$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$	+0.77
$I_2(s) + 2e^- \rightarrow 2I^-(aq)$	+0.54
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$	+0.40
$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$	+0.34
$S(s) + 2H^+(aq) + 2e^- \rightarrow H_2S(g)$	+0.14
$2H^+(aq) + 2e^- \rightarrow H_2(g)$	0.00
$Pb^{2+}(aq) + 2e^- \rightarrow Pb(s)$	–0.13
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$	–0.14
$Ni^{2+}(aq) + 2e^- \rightarrow Ni(s)$	–0.23
$Co^{2+}(aq) + 2e^- \rightarrow Co(s)$	–0.28
$Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$	–0.44
$Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$	–0.76
$2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$	–0.83
$Mn^{2+}(aq) + 2e^- \rightarrow Mn(s)$	–1.03
$Al^{3+}(aq) + 3e^- \rightarrow Al(s)$	–1.67
$Mg^{2+}(aq) + 2e^- \rightarrow Mg(s)$	–2.34
$Na^+(aq) + e^- \rightarrow Na(s)$	–2.71
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s)$	–2.87
$K^+(aq) + e^- \rightarrow K(s)$	–2.93
$Li^+(aq) + e^- \rightarrow Li(s)$	–3.02

Periodic table of the elements

1 H 1.0																	2 He 4.0
3 Li 6.9	4 Be 9.0											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.1
11 Na 23.0	12 Mg 24.3											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 44.9	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.9	27 Co 58.9	28 Ni 58.7	29 Cu 63.6	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8
37 Rb 85.5	38 Sr 87.6	39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc 98.1	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 197.0	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)															

Lanthanides

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.3	63 Eu 152.0	64 Gd 157.2	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0

Actinides

90 Th 232.0	91 Pa 231.0	92 U 238.0	93 Np 237.1	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (255)	103 Lr (256)