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**ADVANCED**  
**General Certificate of Education**  
**2017**

Centre Number

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Candidate Number

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# Chemistry

Assessment Unit A2 1

*assessing*

Periodic Trends and Further  
 Organic, Physical and  
 Inorganic Chemistry



**[AC212]**

\*AC212\*

**TUESDAY 13 JUNE, AFTERNOON**

## TIME

2 hours.

## INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all nineteen** questions.

Answer **all ten** questions in **Section A**. Record your answers by marking the appropriate letter on the answer sheet provided. Use only the spaces numbered 1 to 10. Keep in sequence when answering.

Answer **all nine** questions in **Section B**.

**You must answer the questions in the spaces provided.**

**Do not write outside the boxed area on each page or on blank pages.**

Complete in black ink only. **Do not write with a gel pen.**

## INFORMATION FOR CANDIDATES

The total mark for this paper is 120.

Quality of written communication will be assessed in Question **16(b)**.

In Section A all questions carry equal marks, i.e. **two** marks for each question.

In Section B the figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

A Periodic Table of Elements, containing some data, is included in this question paper.

10568.04R



\*24AC21201\*

## Section A

For each of the following questions only **one** of the lettered responses (A–D) is correct.

**Select the correct response in each case and mark its code letter by connecting the dots as illustrated on the answer sheet.**

- 1 X and Y react according to the equation:



The rate equation for the reaction is:

$$\text{Rate} = k[X]^0[Y]^2$$

Which one of the following is the mechanism for the reaction?

- A  $X + Y \xrightarrow{\text{fast}} XY$        $XY + Y \xrightarrow{\text{slow}} XY_2$
- B  $X + Y \xrightarrow{\text{slow}} XY$        $XY + Y \xrightarrow{\text{fast}} XY_2$
- C  $Y + Y \xrightarrow{\text{fast}} Y_2$        $X + Y_2 \xrightarrow{\text{slow}} XY_2$
- D  $Y + Y \xrightarrow{\text{slow}} Y_2$        $X + Y_2 \xrightarrow{\text{fast}} XY_2$

- 2 The pH range and associated colour changes for the indicators methyl red and bromothymol blue are given below.

indicator	pH range	colour change
methyl red	4.2–6.3	red to yellow
bromothymol blue	6.0–7.6	yellow to blue

A solution which turns both indicators yellow is

- A strongly acidic.
- B weakly acidic.
- C strongly basic.
- D weakly basic.



- 3 The partition coefficient of solute X between trichloroethane and water is 4. A solution containing 20 g of X in 100 cm<sup>3</sup> of water is extracted with two 100 cm<sup>3</sup> portions of trichloroethane in succession. What mass of X is removed by the trichloroethane?
- A 0.8 g  
B 4.0 g  
C 16.0 g  
D 19.2 g
- 4 Which one of the following alcohols can **not** be oxidised with acidified potassium dichromate solution?
- A 2-methylbutan-1-ol  
B 2-methylbutan-2-ol  
C 3-methylbutan-1-ol  
D 3-methylbutan-2-ol
- 5 Which one of the following molecules, when reduced with lithium, forms optically active isomers?
- A CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CHO  
B CH<sub>3</sub>CH<sub>2</sub>COCH<sub>3</sub>  
C CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>CHO  
D CH<sub>3</sub>CH<sub>2</sub>COCH<sub>2</sub>CH<sub>3</sub>

[Turn over

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\*24AC21203\*

- 6 Lard has a saponification value of 193. What volume of  $0.1 \text{ mol dm}^{-3}$  potassium hydroxide solution is required to completely hydrolyse 0.96 g of lard?
- A  $33.1 \text{ cm}^3$   
B  $34.5 \text{ cm}^3$   
C  $331 \text{ cm}^3$   
D  $345 \text{ cm}^3$
- 7 Which one of the following reactions will **not** form propanoic acid?
- A Acid catalysed hydrolysis of ethyl propanoate  
B Acid catalysed hydrolysis of propyl ethanoate  
C Acid catalysed hydrolysis of propanenitrile  
D Oxidation of propan-1-ol
- 8 Concentrated sulfuric acid and concentrated nitric acid react to form a nitrating mixture according to the equation:



Which one of the following statements is correct?

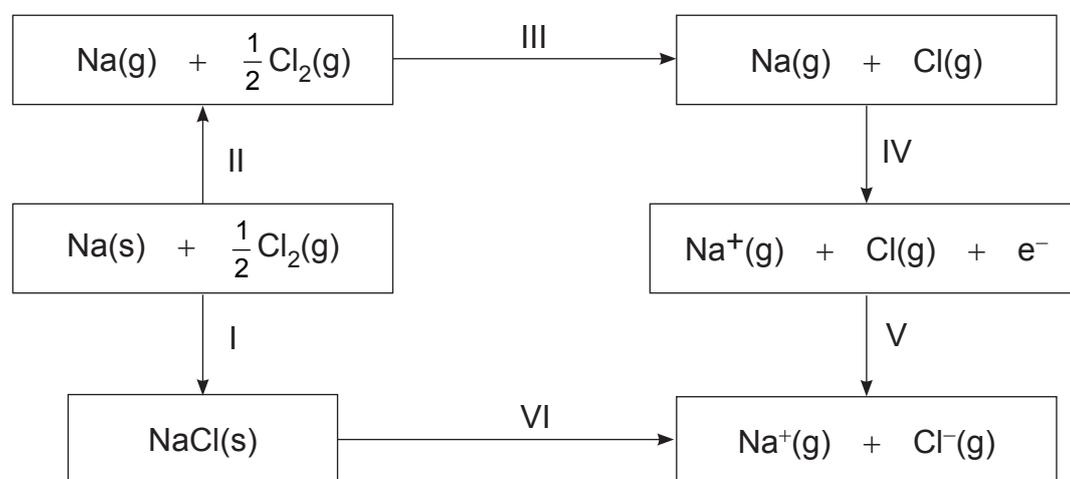
- A Nitric acid is acting as an acid  
B Nitric acid is acting as an oxidising agent  
C Sulfuric acid is acting as an acid  
D Sulfuric acid is acting as an oxidising agent



9 Ethanoic acid has a  $K_a$  of  $2 \times 10^{-5} \text{ mol dm}^{-3}$ . How many moles of sodium ethanoate must be added to  $500 \text{ cm}^3$  of  $0.1 \text{ mol dm}^{-3}$  ethanoic acid to produce a buffer of pH 5?

- A 0.1  
 B 0.2  
 C 0.3  
 D 0.4

10 The diagram below represents the Born–Haber cycle for sodium chloride.



In which one of the following are both steps exothermic?

- A I and V  
 B II and IV  
 C IV and VI  
 D V and VI



## Section B

Answer **all nine** questions in this section.

11 (a) Complete the table below for some of the oxides and chlorides in Period 3.

	MgO	Al <sub>2</sub> O <sub>3</sub>	P <sub>4</sub> O <sub>10</sub>	MgCl <sub>2</sub>
type of bonding				
approximate pH of aqueous solution, if formed				

[4]

(b) Write equations for the following reactions.

(i) Magnesium oxide with nitric acid.

\_\_\_\_\_

[1]

(ii) Aluminium oxide with sodium hydroxide solution.

\_\_\_\_\_

[1]

(iii) Phosphorus(V) oxide with water.

\_\_\_\_\_

[1]

(iv) Phosphorus(V) chloride with water.

\_\_\_\_\_

[1]



(c) The lattice enthalpy of magnesium chloride is  $2489 \text{ kJ mol}^{-1}$ .

(i) Explain what is meant by the term **lattice enthalpy**.

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[2]

(ii) Use the lattice enthalpy of magnesium chloride and the information below to calculate the enthalpy of hydration for one mole of chloride ions.

Enthalpy of solution of magnesium chloride =  $-170 \text{ kJ mol}^{-1}$

Enthalpy of hydration of magnesium ions =  $-1891 \text{ kJ mol}^{-1}$

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[2]

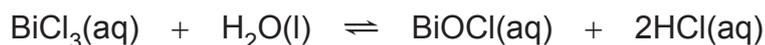


12 Equilibrium reactions are found in many areas of chemistry.

- (a) (i) Bismuth carbonate,  $\text{Bi}_2(\text{CO}_3)_3$ , reacts with hydrochloric acid to form a colourless solution of bismuth chloride,  $\text{BiCl}_3$ . Write an equation for the reaction.

\_\_\_\_\_ [2]

- (ii) If the bismuth chloride solution is diluted the following equilibrium is set up:



Explain how the following changes affect the position of the equilibrium.

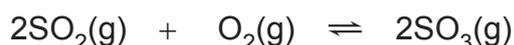
Adding water:

\_\_\_\_\_  
\_\_\_\_\_ [2]

Adding sodium hydroxide solution:

\_\_\_\_\_  
\_\_\_\_\_ [2]

- (b) A mixture of 2 moles of  $\text{SO}_2$  and 1 mole of  $\text{O}_2$  were allowed to reach equilibrium in a  $2\text{ dm}^3$  container.



At equilibrium 75% of the  $\text{SO}_2$  was converted to  $\text{SO}_3$ . Calculate the value of  $K_c$  and state its units.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [4]





**13** Carbon dioxide, CO<sub>2</sub>, methane, CH<sub>4</sub>, and nitrogen(I) oxide, N<sub>2</sub>O, are considered to be greenhouse gases.

**(a) (i)** State **three** natural processes upon which the concentration of carbon dioxide in the atmosphere depends and how they affect this concentration.

- 1. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  - 2. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  - 3. \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
- [3]

**(ii)** Suggest how methane and nitrogen(I) oxide act as greenhouse gases.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

[2]

**(b)** Nitrogen(I) oxide is approximately 20 times more effective as a greenhouse gas than methane. Suggest why methane is of greater concern as a greenhouse gas than nitrogen(I) oxide.

\_\_\_\_\_  
\_\_\_\_\_

[1]

**[Turn over**

10568.04R



14 Entropy is an important concept when establishing the feasibility of a reaction.

(a) Explain what is meant by the term **entropy**.

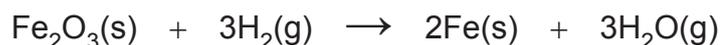
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[1]

(b) Iron(III) oxide can be reduced to iron.



The table below gives the enthalpies of formation and the entropies of the reactants and products.

	$\text{Fe}_2\text{O}_3(\text{s})$	$\text{H}_2(\text{g})$	$\text{Fe}(\text{s})$	$\text{H}_2\text{O}(\text{g})$
$\Delta H_f / \text{kJ mol}^{-1}$	-822	0	0	-242
$S / \text{kJ mol}^{-1} \text{K}^{-1}$	0.09	0.13	0.03	0.19

(i) Why are the  $\Delta H_f$  values of  $\text{Fe}(\text{s})$  and  $\text{H}_2(\text{g})$  zero?

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[1]

(ii) Calculate the enthalpy change for the reaction.

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[2]



(iii) Calculate the entropy change for the reaction.

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[2]

(iv) Use your answers to parts (ii) and (iii) to calculate the temperature at which the reaction becomes feasible.

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[2]

(v) Explain why the reaction may not take place at this temperature.

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[1]

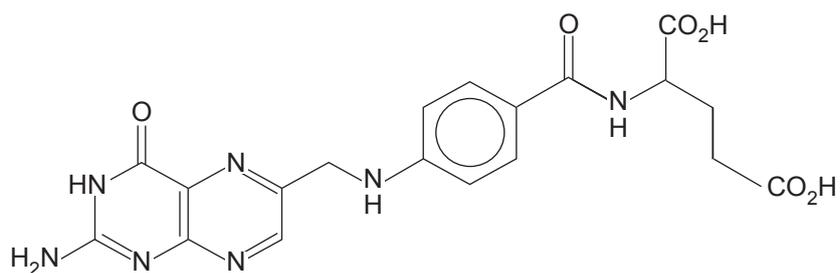
[Turn over

10568.04R



\*24AC21211\*

15 Folic acid is an essential nutrient in our diet.



folic acid

(a) Folic acid contains an asymmetric centre, making it optically active.

(i) Explain what is meant by the term **asymmetric centre**.

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[1]

(ii) Explain what is meant by the term **optically active**.

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[2]

(iii) On the diagram of folic acid above, circle the asymmetric centre.

[1]



(b) (i) What is the molecular formula of folic acid?

\_\_\_\_\_ [1]

(ii) The solubility of folic acid is  $6.1 \times 10^{-3} \text{ g dm}^{-3}$ . Calculate the molarity of this solution of folic acid.

\_\_\_\_\_  
\_\_\_\_\_ [2]

(c) The first  $\text{pK}_a$  of folic acid is 4.65.

(i) Explain why folic acid has more than one  $\text{pK}_a$ .

\_\_\_\_\_ [1]

(ii) Using the first  $\text{pK}_a$ , calculate the pH of a  $1 \times 10^{-5} \text{ mol dm}^{-3}$  solution of folic acid.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [3]

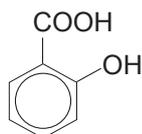
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10568.04R



\*24AC21213\*

16 Salicylic acid can be esterified to form 'oil of wintergreen' and aspirin.



salicylic acid

- (a) (i) 'Oil of wintergreen' is made by esterification of salicylic acid with methanol. Draw the structure of 'oil of wintergreen'.

[1]

- (ii) Suggest the non-systematic name for the ester 'oil of wintergreen'.

[1]

- (iii) Aspirin can be made by esterification of salicylic acid with ethanoic acid. Draw the structure of aspirin.

[1]

- (iv) Suggest an alternative reagent to ethanoic acid in the formation of aspirin and give **one** advantage of using this reagent.

[2]





17 Fats and vegetable oils are triesters formed from fatty acids and propane-1,2,3-triol.

- (a) Palmitic acid,  $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$ , and oleic acid,  $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$ , are fatty acids. Suggest why palmitic acid is a solid at room temperature and oleic acid is a liquid.

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[2]

- (b) Cervonic acid is an unsaturated fatty acid.



cervonic acid

Unsaturated fats can be hardened by catalytic hydrogenation.

- (i) Explain what is meant by the term **hydrogenation**.

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[1]

- (ii) Name the catalyst used in the hardening of unsaturated fatty acids.

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[1]



(iii) Calculate the iodine value for cervonic acid.

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[3]

(c) Explain the role of polyunsaturates and polysaturates in a healthy diet.

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[3]

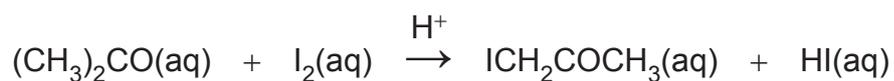
[Turn over

10568.04R



\*24AC21217\*

18 (a) The reaction between propanone and iodine is catalysed by acid.



(i) State how the reaction could be “quenched” i.e. stopped without interfering with any of the reactants or products.

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[1]

(ii) Explain how you could determine the rate of the reaction by an acid–base titration.

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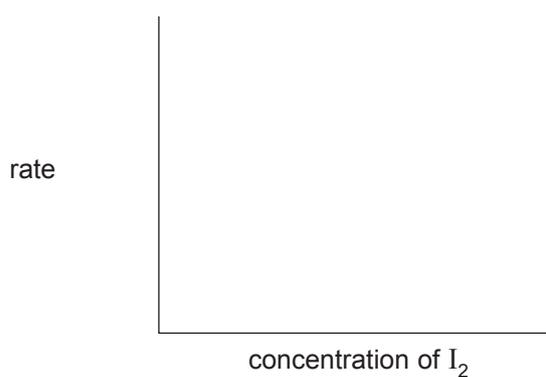
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[4]

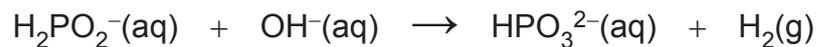
(iii) The reaction is zero order with respect to the iodine. Sketch a “rate against concentration” graph.



[1]



- (b) Phosphinate ions,  $\text{H}_2\text{PO}_2^-$ , are found in insecticides and herbicides. The rate of the reaction between phosphinate ions and hydroxide ions was investigated.



The following results were obtained.

$[\text{H}_2\text{PO}_2^-(\text{aq})]$ /mol dm <sup>-3</sup>	$[\text{OH}^-(\text{aq})]$ /mol dm <sup>-3</sup>	initial rate of $\text{H}_2(\text{g})$ formation /cm <sup>3</sup> min <sup>-1</sup>
0.1	0.1	2.4
0.1	0.2	9.6
0.2	0.3	43.2

- (i) Deduce the rate equation.

\_\_\_\_\_ [2]

- (ii) What is the overall order of the reaction?

\_\_\_\_\_ [1]

- (iii) Calculate the rate constant and state its units.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

- (iv) Suggest the disadvantages of using artificial phosphate fertiliser.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_ [2]

[Turn over

10568.04R



\*24AC21219\*

19 Glutaraldehyde,  $\text{OHC}(\text{CH}_2)_3\text{CHO}$ , is used to sterilise dental equipment.

(a) Suggest the systematic name for glutaraldehyde.

\_\_\_\_\_ [1]

(b) Explain why glutaraldehyde is soluble in water.

\_\_\_\_\_  
\_\_\_\_\_ [1]

(c) (i) State the colour change observed when glutaraldehyde is reacted with Fehling's solution.

\_\_\_\_\_ [1]

(ii) Give the formulae of the metal ions responsible for the colour change.

\_\_\_\_\_ [1]

(d) Glutaraldehyde can be formed by oxidising the corresponding alcohol.

(i) Write an equation, using [O] to represent the oxidising agent, for the formation of glutaraldehyde from the alcohol.

\_\_\_\_\_ [1]

(ii) The oxidising agent is acidified potassium dichromate. State the condition necessary for this reaction.

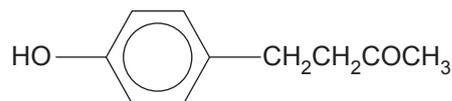
\_\_\_\_\_ [1]

(iii) State the colour change that would be observed during the reaction.

\_\_\_\_\_ [1]



(e) The smell and flavour of raspberries is due in part to the 'raspberry ketone'.



'raspberry ketone'

(i) Draw the mechanism for the reaction of 'raspberry ketone' with hydrogen cyanide. Use RCOCH<sub>3</sub> to represent the ketone.

[3]

(ii) Write the equation for the reaction of 'raspberry ketone' with 2,4-dinitrophenylhydrazine. Use RCOCH<sub>3</sub> to represent the ketone.

[2]

(iii) Suggest how the product of the reaction in part (ii) could be used to confirm the identity of the 'raspberry ketone'.

\_\_\_\_\_

\_\_\_\_\_ [1]

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For Examiner's use only	
Question Number	Marks
Section A	
1–10	
Section B	
11	
12	
13	
14	
15	
16	
17	
18	
19	
<b>Total Marks</b>	

Examiner Number

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217602



\*24AC21224\*



# Periodic Table of the Elements

For the use of candidates taking  
Advanced Subsidiary and Advanced Level  
Chemistry Examinations

**Copies must be free from notes or additions of any kind. No other type of data booklet or information sheet is authorised for use in the examinations.**

# gce A/AS examinations chemistry (advanced)

I		II		THE PERIODIC TABLE OF ELEMENTS Group																III	IV	V	VI	VII	0
1 <b>H</b> Hydrogen 1	One mole of any gas at 20°C and a pressure of 1 atmosphere (10 <sup>5</sup> Pa) occupies a volume of 24 dm <sup>3</sup> . Planck Constant = 6.63 × 10 <sup>-34</sup> Js Gas Constant = 8.31 J mol <sup>-1</sup> K <sup>-1</sup> Avogadro Constant = 6.02 × 10 <sup>23</sup> mol <sup>-1</sup>																4 <b>He</b> Helium 2								
7 <b>Li</b> Lithium 3	9 <b>Be</b> Beryllium 4																	11 <b>B</b> Boron 5	12 <b>C</b> Carbon 6	14 <b>N</b> Nitrogen 7	16 <b>O</b> Oxygen 8	19 <b>F</b> Fluorine 9	20 <b>Ne</b> Neon 10		
23 <b>Na</b> Sodium 11	24 <b>Mg</b> Magnesium 12																	27 <b>Al</b> Aluminium 13	28 <b>Si</b> Silicon 14	31 <b>P</b> Phosphorus 15	32 <b>S</b> Sulfur 16	35.5 <b>Cl</b> Chlorine 17	40 <b>Ar</b> Argon 18		
39 <b>K</b> Potassium 19	40 <b>Ca</b> Calcium 20	45 <b>Sc</b> Scandium 21	48 <b>Ti</b> Titanium 22	51 <b>V</b> Vanadium 23	52 <b>Cr</b> Chromium 24	55 <b>Mn</b> Manganese 25	56 <b>Fe</b> Iron 26	59 <b>Co</b> Cobalt 27	59 <b>Ni</b> Nickel 28	64 <b>Cu</b> Copper 29	65 <b>Zn</b> Zinc 30	70 <b>Ga</b> Gallium 31	73 <b>Ge</b> Germanium 32	75 <b>As</b> Arsenic 33	79 <b>Se</b> Selenium 34	80 <b>Br</b> Bromine 35	84 <b>Kr</b> Krypton 36								
85 <b>Rb</b> Rubidium 37	88 <b>Sr</b> Strontium 38	89 <b>Y</b> Yttrium 39	91 <b>Zr</b> Zirconium 40	93 <b>Nb</b> Niobium 41	96 <b>Mo</b> Molybdenum 42	99 <b>Tc</b> Technetium 43	101 <b>Ru</b> Ruthenium 44	103 <b>Rh</b> Rhodium 45	106 <b>Pd</b> Palladium 46	108 <b>Ag</b> Silver 47	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	119 <b>Sn</b> Tin 50	122 <b>Sb</b> Antimony 51	128 <b>Te</b> Tellurium 52	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54								
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56	139 <b>La</b> * Lanthanum 57	178 <b>Hf</b> Hafnium 72	181 <b>Ta</b> Tantalum 73	184 <b>W</b> Tungsten 74	186 <b>Re</b> Rhenium 75	190 <b>Os</b> Osmium 76	192 <b>Ir</b> Iridium 77	195 <b>Pt</b> Platinum 78	197 <b>Au</b> Gold 79	201 <b>Hg</b> Mercury 80	204 <b>Tl</b> Thallium 81	207 <b>Pb</b> Lead 82	209 <b>Bi</b> Bismuth 83	210 <b>Po</b> Polonium 84	210 <b>At</b> Astatine 85	222 <b>Rn</b> Radon 86								
223 <b>Fr</b> Francium 87	226 <b>Ra</b> Radium 88	227 <b>Ac</b> † Actinium 89																							

\* 58–71 Lanthanum series

† 90–103 Actinium series

a	x
b	

a = relative atomic mass (approx.)  
x = atomic symbol  
b = atomic number

140 <b>Ce</b> Cerium 58	141 <b>Pr</b> Praseodymium 59	144 <b>Nd</b> Neodymium 60	147 <b>Pm</b> Promethium 61	150 <b>Sm</b> Samarium 62	152 <b>Eu</b> Europium 63	157 <b>Gd</b> Gadolinium 64	159 <b>Tb</b> Terbium 65	162 <b>Dy</b> Dysprosium 66	165 <b>Ho</b> Holmium 67	167 <b>Er</b> Erbium 68	169 <b>Tm</b> Thulium 69	173 <b>Yb</b> Ytterbium 70	175 <b>Lu</b> Lutetium 71
232 <b>Th</b> Thorium 90	231 <b>Pa</b> Protactinium 91	238 <b>U</b> Uranium 92	237 <b>Np</b> Neptunium 93	242 <b>Pu</b> Plutonium 94	243 <b>Am</b> Americium 95	247 <b>Cm</b> Curium 96	245 <b>Bk</b> Berkelium 97	251 <b>Cf</b> Californium 98	254 <b>Es</b> Einsteinium 99	253 <b>Fm</b> Fermium 100	256 <b>Md</b> Mendelevium 101	254 <b>No</b> Nobelium 102	257 <b>Lr</b> Lawrencium 103