Index No:_____ **IM 06.15s**

MATRICULATION AND SECONDARY EDUCATION CERTIFICATE EXAMINATIONS BOARD

UNIVERSITY OF MALTA, MSIDA

MATRICULATION EXAMINATION
INTERMEDIATE LEVEL
SEPTEMBER 2015

SUBJECT:	CHEMISTRY
DATE:	4th September 2015
TIME:	4.00 p.m. to 7.00 p.m.

Useful information: The molar gas constant R = 8.31 J K^{-1} mol^{-1}
Relative atomic masses: Fe = 56

A Periodic Table is included.

Section A
Answer ALL questions in this Section

1. (a) Complete the blank boxes in following Table:

Symbol	Atomic number	Mass number	Number of protons	Number of neutrons
$^{14}_{6}C$				
$^{14}_{7}N$				
			3	3

(6 marks)

(b) Consider $^{14}_{6}C$ and $^{14}_{7}N$, and explain briefly whether they are isotopes or not.

_____

_____

_____

(2 marks)
(Total: 8 marks)

2. There are single and multiple covalent bonds.
(a) Give the molecular formula and the structural formula of **one** molecule containing single covalent bonds only.

_____

(2 marks)

(b) Give the molecular formula and the structural formula of **one** molecule containing multiple bonds.

_____

(2 marks)

(c) Give the name of a homologous series of organic compounds containing multiple bonds.

_____

(1 mark)

(Total: 5 marks)

3. Write the chemical equations for the following two reactions:

(a) The reaction of one mole of methane with one mole of chlorine gas.

_____

(2 marks)

(b) The reaction of ethanol with ethanoic acid.

_____

(2 marks)

(Total: 4 marks)

4. **Underline** the correct term to complete the following statements.

(i) Sodium chloride, being an ionic compound, is soluble in **POLAR / NON-POLAR** solvents.

(1 mark)

(ii) Carbon dioxide is a gas at room temperature; it has a low boiling point because its **INTRAMOLECULAR / INTERMOLECULAR** forces are **STRONG / WEAK**.

(2 marks)

(iii) The attraction between water molecules is mainly due to **VAN DER WAALS FORCES / HYDROGEN BONDING**.

(1 mark)

(Total: 4 marks)

5. Consider the following equilibrium reaction:

$$N_2\,(g) + 3H_2\,(g) \rightleftharpoons 2NH_3\,(g)\ \Delta H = -92.4\ kJmol^{-1}$$

After equilibrium is reached, predict what happens in terms of equilibrium shift, if any, if:

(i) The concentration of nitrogen gas is increased.

_____

_____

(1 mark)

(ii) The pressure on the equilibrium gaseous mixture is increased.

_____

_____

(2 marks)

(iii) The temperature of the equilibrium gaseous mixture is increased.

_____

_____

(2 marks)

(iv) A suitable catalyst is added.

_____

_____

(2 marks)
(Total: 7 marks)

6. (a) Distinguish between primary, secondary and tertiary amines in terms of structure.

_____

_____

_____

_____

_____

(3 marks)

(b) How can nitrobenzene be converted to phenylamine? The balanced equation is not necessary.

_____

_____

(2 marks)
(Total: 5 marks)

Please turn the page.

7. The vast majority of chemical reactions take place through a *reaction mechanism*. The mechanism has a *rate-determining step*.

(i) Explain briefly what is meant by the term '*reaction mechanism*'.

_____

_____

(1 mark)

(ii) Explain briefly the term '*rate-determining step*'.

_____

_____

_____

(2 marks)
(Total: 3 marks)

8. Consider the following hypothetical reaction, and its ΔH value:

$$X + Y \rightarrow Z \qquad \Delta H = -100 \text{ kJmol}^{-1}$$

(a) Draw a reaction profile for this reaction. Label the axes, and indicate the activation energy and the ΔH on the plot.

(4 marks)

(b) On the same plot, draw the profile if a suitable catalyst were to be used for the same reaction.

(1 mark)
(Total: 5 marks)

9. There are acids, bases and alkalis. Acids and bases can be strong or weak.

(a) Distinguish between acids and bases.

_____

_____

(2 marks)

(b) Distinguish between bases and alkalis.

_____

_____

(2 marks)

(c) Distinguish between strong and weak acids or bases.

_____

_____

_____

(2 marks)

(Total: 6 marks)

10. A gas was placed in a closed container of volume 0.05 m^3, at a pressure of 100,000 Pa and a temperature of 27 ^{O}C.

(a) Calculate the number of moles of gas present in the container. Give your answer to one decimal place.

_____

_____

_____

_____

(4 marks)

(b) If the mass of the gas is 32 g, find its relative molecular mass.

_____

_____

(2 marks)

(Total: 6 marks)

Please turn the page.

11. Borane is the name of the compound of formula BH_3.

(a) Draw a dot-and-cross diagram of the molecule showing outer shell electrons only.

(2 marks)

(b) Indicate the shape of this molecule, and the H-B-H bond angle.

_____

_____

(2 marks)

(c) Explain why borane is considered to be an electron deficient compound.

_____

_____

(1 mark)

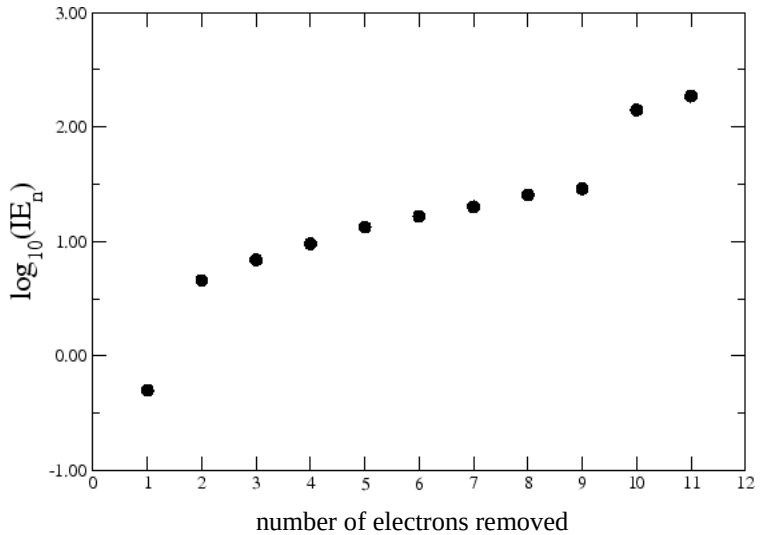
(Total: 5 marks)

12. (a) Sodium is a group I element. Write the electronic configuration of sodium in spdf notation.

_____

(1 mark)

(b) The following is a plot of the eleven successive ionisation energies of sodium. Explain briefly the energy required at the following points on the graph.



(i) The first electron removed:_____

_____

(ii) From electron 2 to electron 9 removed: _____

_____

(iii) Removal of electrons 10 and 11: _____

_____

(iv) The general increase from electron 1 to electron 11: _____

_____

(4 marks)
(Total: 5 marks)

13. The following redox reaction was examined by the Swedish chemist Johan Gadolin in 1788:

$$2\ Sn^{2+} \rightarrow Sn^{4+} + Sn$$

(a) By using oxidation numbers, indicate what is being oxidised and what is being reduced.

_____

_____

_____

_____

(4 marks)

(b) What is this type of reaction called? Explain.

_____

_____

_____

(3 marks)
(Total: 7 marks)

Please turn the page.

14. Consider the following chemical reaction: $3A_2$ (g) + $4D_3$ (g) → $6AD_2$ (g)

(a) Starting with 0.8 moles of D_3 and 1.0 mole of A_2, the number of moles of AD_2 produced is

_____ .

(2 marks)

(b) The number of moles of A_2 that actually react with D_3 is _____ .

(1 mark)

(c) The reactant in excess is _____ .

(1 mark)

(d) The total number of moles of gas in the mixture after the reaction is _____ .

(2 marks)

(Total: 6 marks)

15. Indicate the pH of the following liquids as equal, higher or lower than 7.

(i)	pure water	
(ii)	rain water	
(iii)	dilute sulphuric acid solution	
(iv)	ammonia solution	

(4 marks)

(Total: 4 marks)

Section B
Answer ALL questions in this Section

16. (a) (i) Give the outcomes of the flame test for each of the following:

Sample	Outcome
A sodium salt	
A potassium salt	
A calcium salt	
A barium salt	

(4 marks)

(ii) Outline the procedure for carrying out a flame test.

_____

_____

_____

_____

(4 marks)

(b) Fill in the blanks in the Table below, giving the visible changes (if any) of the following test tube reactions:

Solution containing	+ a few drops of NaOH solution	+ excess NaOH solution	+ a few drops of NH_3 solution	+ excess NH_3 solution
Zn^{2+} ions				
Pb^{2+} ions				

(8 marks)

(Total: 16 marks)

Please turn the page.

17. (a) Describe briefly how each of the following operations can be carried out. Wherever appropriate, indicate the name of the process.

(i) Obtaining sodium chloride crystals from a solution of sodium chloride.

_____

_____

_____

_____

(4 marks)

(ii) Separation of a mixture of calcium carbonate and sodium chloride.

_____

_____

_____

_____

(4 marks)

(iii) Separation of a mixture of iodine crystals and sodium chloride crystals.

_____

_____

_____

_____

(4 marks)

(iv) Separation of the components in a sample of ink.

_____

_____

_____

_____

(4 marks)

(Total: 16 marks)

18. Explain briefly each of the following statements.

(a) The Periodic Table has groups and periods. There are short and long periods.

(4 marks)

(b) Periodicity of the oxides of the elements lithium to chlorine can be shown by their reaction with water.

(7 marks)

(c) One can detect trends in melting points of the oxides crossing a period from left to right.

(5 marks)

(Total: 16 marks)

19. (a) Chemists speak of the *standard enthalpy of neutralisation*.

(i) Define the term *standard enthalpy of neutralisation.*

(4 marks)

(ii) Indicate the '*standard*' conditions.

(2 marks)

(b) Both hydrochloric acid and sulphuric acid solutions react with sodium hydroxide solution. Give the full chemical equation and the ionic equation, including state symbols, for the two reactions.

(4 marks)

(c) The standard enthalpy of neutralisation for both reactions of hydrochloric acid and sulphuric acid solutions with sodium hydroxide solution is given at around -58 $kJmol^{-1}$. The standard enthalpy of neutralisation for the reaction of ethanoic acid with sodium hydroxide solution is given at around -56 $kJmol^{-1}$.

Explain briefly why the value for the reactions with hydrochloric acid and sulphuric acid is different from the value for the reaction with ethanoic acid.

(6 marks)

(Total: 16 marks)

20. (a) The atomic number of zinc is 30. Its relative atomic mass is 65.39 amu. Zinc has a number of naturally occurring isotopes; the most abundant are Zn-64, Zn-66, Zn-67 and Zn-68.

(i) What can be deduced from the fact that its atomic number is 30?

_____

_____

(2 marks)

(ii) Explain briefly why the relative atomic mass of zinc is not a whole number.

_____

_____

_____

_____

(4 marks)

(iii) What does '*amu*' stand for? Define this unit.

_____

_____

_____

(3 marks)

(b) Another isotope of zinc is Zn-71. Its half-life is 2.4 minutes.

(i) Define the term '*half-life*'.

_____

_____

_____

(2 marks)

(ii) If the original amount of Zn-71 is 50.0 g, how much (in g) would be left after 9.6 minutes. Give your answer to two decimal places.

_____

_____

_____

_____

(5 marks)

(Total: 16 marks)

Section C
Answer TWO questions from this Section

21. (a) Define the term *standard solution.* (2 marks)

(b) You are provided with between 2.5 g and 2.8 g of anhydrous sodium carbonate and you are required to make up a *standard solution of sodium carbonate*. Outline a simple procedure to carry out this task. (8 marks)

(c) The standard solution prepared has a concentration of 0.10 $moldm^{-3}$, and is used in a titration with hydrochloric acid solution of unknown concentration. 25.00 cm^3 of the standard sodium carbonate solution is pipetted into a conical flask and is titrated with hydrochloric acid solution from the burette until the endpoint is reached. The indicator is methyl orange and the titre value is 19.50 cm^3.

(i) Define the term '*end-point*'. (2 marks)

(ii) Calculate the concentration of the hydrochloric acid solution. (8 marks)

(d) The reaction between sodium carbonate and hydrochloric acid is an example of an acid-base titration. It is possible however to perform other types of titrations, such as redox titrations. The analysis of *iron tablets* by titrating with *potassium manganate(VII) solution* in acid is one such example of a redox titration.

(i) The reaction hereunder can be written as two half equations.
$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$
Indicate, by writing half-equations, the oxidation and the reduction half-reactions. (4 marks)

(ii) Given that 5g of iron tablets (5 tablets weighing 1 g each) require 12.5 cm^3 of 0.90 $moldm^{-3}$ $KMnO_4$, calculate the mass of Fe^{2+} in each tablet. (10 marks)

(e) Describe a simple test tube reaction to determine whether any iron(II) ions are still in solution. Indicate how this would be different from having iron(III) only. (6 marks)

(Total: 40 marks)

22. (a) Define the terms *ionic bonding*, *covalent bonding* and *metallic bonding.* (12 marks)

(b) Draw the structure of each of the solids hereunder and put a tick into the box (or boxes) to show the type(s) of bond present.

	Ionic Bonds	**Covalent Bonds**	**Dative Covalent Bonds**	**Metallic Bonds**
calcium chloride				
carbon dioxide				
silicon oxide				
graphite				
mercury				
ammonium chloride				

(12 + 6 marks)

(c) (i) Distinguish between the structure of graphite and that of diamond. *Use diagrams in your explanation.* (6 marks)

(ii) State and briefly explain the major difference in physical properties that exists between the two solids that is attributed to the type of bonding in each. (4 marks)

(Total: 40 marks)

23. (a) A lab analyst wanted to illustrate the effect of using a *catalyst* on the rate of reaction. MnO_2 was used as a catalyst in the decomposition of hydrogen peroxide. Write a balanced chemical equation for the decomposition of hydrogen peroxide. (3 marks)

(b) The rate of reaction was followed by determining the volume of gas produced over time. The results for the decomposition of two hydrogen peroxide solutions of different concentration are reported in the table hereunder. The same quantity of catalyst was used in both cases.

Time (s)	**Volume of gas using 0.5 moldm^{-3} solution (cm^3)**	**Volume of gas using 1.0 moldm^{-3} solution (cm^3)**
0	0	0
30	29	45
60	55	84
90	79	118
120	98	145
150	118	162
180	133	174
210	146	182

(i) Draw a typical set-up that could be used to follow the rate of reaction of hydrogen peroxide decomposition. (5 marks)

(ii) Using the numerical data above, draw a graph (on page 23) to show the volume of gas produced against time, when 0.5 moldm^{-3} hydrogen peroxide solution is used. (6 marks)

(iii) On the same set of axes, draw another graph to show the volume of gas produced against time, when 1.0 moldm^{-3} hydrogen peroxide solution is used. (4 marks)

(c) (i) At which stage does the reaction proceed most quickly? Explain your reasoning in terms of particles. (6 marks)

(ii) From the graph, give the volume of gas produced at 50 s when using 0.5 moldm^{-3} hydrogen peroxide solution. (2 marks)

(iii) Why does the slope of the graph become less steep as the reaction proceeds? (6 marks)

(d) (i) Define the term '*catalyst*'. (2 marks)

(ii) Catalysts are reaction specific. Explain briefly. (2 marks)

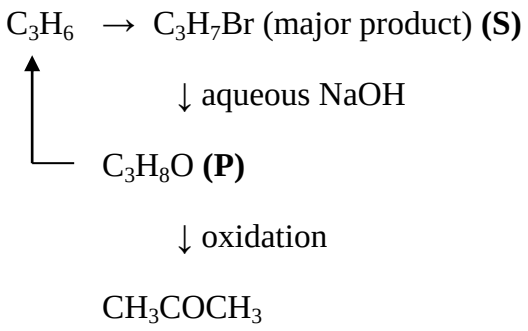
(iii) Explain briefly why manganese is suitable for acting as a catalyst. (2 marks)

(iv) Explain the term '*poisoned catalyst*'. (2 marks)

(Total: 40 marks)

Please turn the page.

24. (a) Consider the following reaction scheme:



(i) State the type of reaction occurring in the conversion $C_3H_6 \rightarrow C_3H_7Br$, and give the reagents needed for this reaction. (4 marks)

(ii) Give the structural formula of the compounds marked **S** and **P**. (2 marks)

(iii) Give the reagents needed for the reaction $C_3H_8O \rightarrow CH_3COCH_3$. (2 marks)

(iv) State the type of reaction occurring in the conversion $C_3H_8O \rightarrow C_3H_6$, and give the reagents needed for this reaction. (4 marks)

(b) '*The reaction between 1-butene and hydrochloric acid is an addition reaction*.'

(i) Explain the term *addition reaction*. (2 marks)

(ii) Distinguish between an *addition reaction* and a *substitution reaction*. Illustrate your answer with a suitable example in each case. (6 marks)

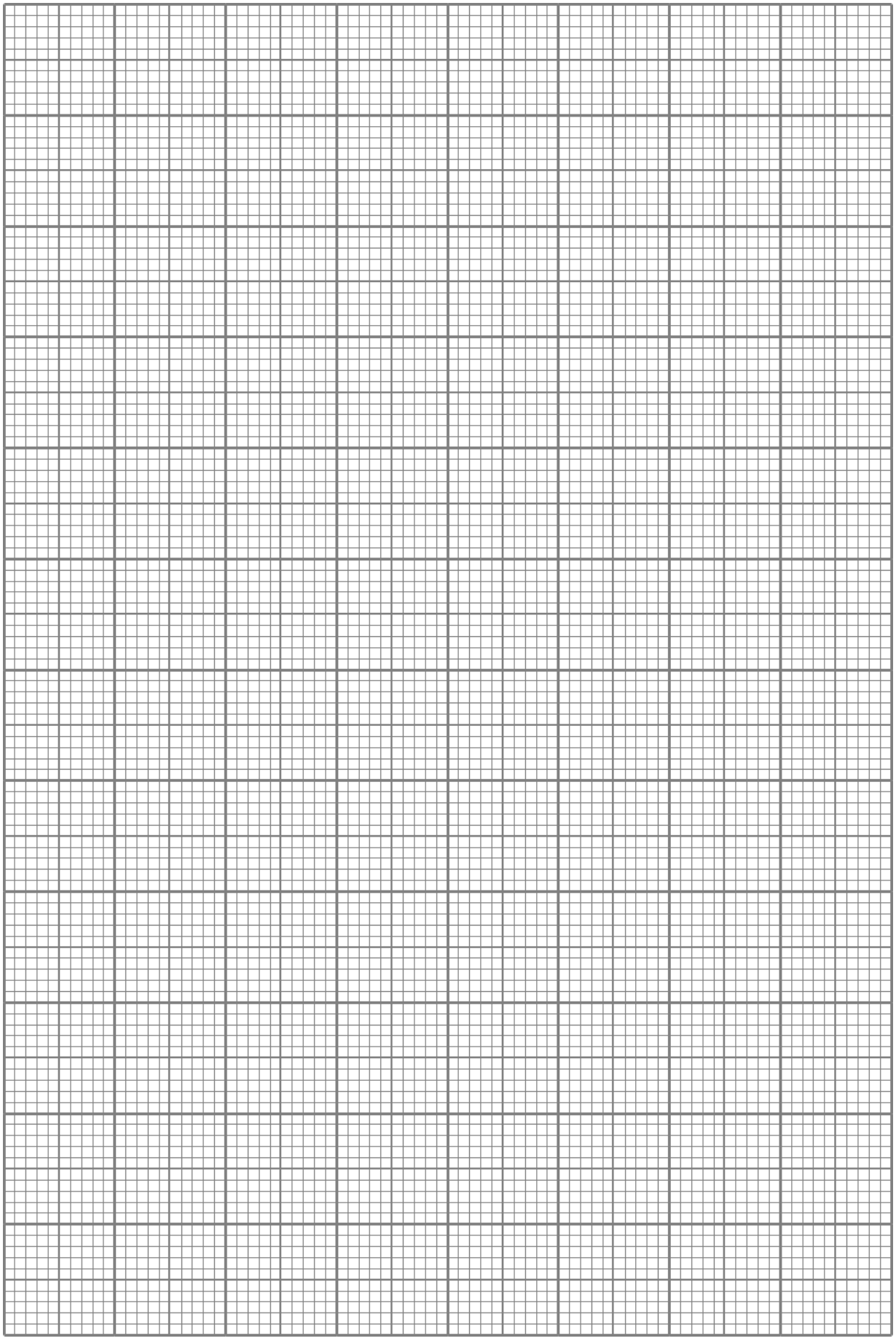
(c) State Markovnikov's rule and predict the major product of the reaction between 1-butene and hydrochloric acid. Explain your reasoning, giving the chemical equation for the reaction and the structural formula of the major product. (7 marks)

(d) (i) Give the structural formula and the name for an isomer of P. (4 marks)

(ii) Give a chemical test that distinguishes between the two isomers. (6 marks)

(e) Give a chemical test that distinguishes between an alkene and an aromatic compound. (3 marks)

(Total: 40 marks)



PERIODIC TABLE

I	II											III	IV	V	VI	VII	VIII
																	4 **He** 2
7 **Li** 3	9 **Be** 4											11 **B** 5	12 **C** 6	14 **N** 7	16 **O** 8	19 **F** 9	20 **Ne** 10
23 **Na** 11	24 **Mg** 12											27 **Al** 13	28 **Si** 14	31 **P** 15	32 **S** 16	35.5 **Cl** 17	40 **Ar** 18
39 **K** 19	40 **Ca** 20	45 **Sc** 21	48 **Ti** 22	51 **V** 23	52 **Cr** 24	55 **Mn** 25	56 **Fe** 26	59 **Co** 27	59 **Ni** 28	63.5 **Cu** 29	65 **Zn** 30	70 **Ga** 31	73 **Ge** 32	75 **As** 33	79 **Se** 34	80 **Br** 35	84 **Kr** 36
85 **Rb** 37	88 **Sr** 38	89 **Y** 39	91 **Zr** 40	93 **Nb** 41	96 **Mo** 42	99 **Tc** 43	101 **Ru** 44	103 **Rh** 45	106 **Pd** 46	108 **Ag** 47	112 **Cd** 48	115 **In** 49	119 **Sn** 50	122 **Sb** 51	128 **Te** 52	127 **I** 53	131 **Xe** 54
133 **Cs** 55	137 **Ba** 56	139 **La** 57	178.5 **Hf** 72	181 **Ta** 73	184 **W** 74	186 **Re** 75	190 **Os** 76	192 **Ir** 77	195 **Pt** 78	197 **Au** 79	201 **Hg** 80	204 **Tl** 81	207 **Pb** 82	209 **Bi** 83	209 **Po** 84	210 **At** 85	222 **Rn** 86
223 **Fr** 87	226 **Ra** 88	227 **Ac** 89															

Key

Relative atomic mass — A, X, Z — *Atomic Number*

140 **Ce** 58	141 **Pr** 59	144 **Nd** 60	147 **Pm** 61	150 **Sm** 62	152 **Eu** 63	157 **Gd** 64	159 **Tb** 65	162 **Dy** 66	165 **Ho** 67	167 **Er** 68	169 **Tm** 69	173 **Yb** 70	175 **Lu** 71
232 **Th** 90	231 **Pa** 91	238 **U** 92	237 **Np** 93	244 **Pu** 94	243 **Am** 95	247 **Cm** 96	247 **Bk** 97	251 **Cf** 98	252 **Es** 99	257 **Fm** 100	258 **Md** 101	259 **No** 102	260 **Lr** 103