UNIVERSITY OF SWAZILAND

RE-SIT EXAMINATION – 2016, MAY

TITLE OF PAPER : Introductory Chemistry II

COURSE NUMBER : CHE 152

TIME : Three Hours

INSTRUCTIONS :

1. **Answer all questions in Section A** (Total 40 marks)
2. **Answer any two questions in Section B** (each question is 20 marks)

NB: Non-programmable electronic calculators may be used
A data sheet, a periodic table and answer sheet (for **Section A**) are attached

Useful data and equations:

1 atm = 760 Torr = 760 mmHg

1 atm = 101325 Pa

Arrhenius equation: $k = Ae^{-E_a/RT}$ or $lnk = lnA - \frac{E_a}{RT}$

Van der Walls equation: $P = \frac{nRT}{V-nb} - \frac{n^2a}{V^2}$

This Examination Paper Contains Six Printed Pages Including This Page

You are not supposed to open the paper until permission to do so has been grated by the Chief Invigilator.

SECTION A

1. The pressure of hydrogen sulfide gas in a container is 35,650 Pa. What is this pressure in torr?

A.	46.91 torr	B.	267.4 torr	C.	351.8 torr
D.	3612 torr	E.	27,090 torr		

2. "The pressure of an ideal gas is inversely proportional to its volume at constant temperature and number of moles" is a statement of ________________ Law.

A.	Charles'	B.	Boyle's	C.	Amontons'
D.	Avogadro's	E.	Gay-Lussac's		

3. A sample of an ideal gas has its volume doubled while its temperature remains constant. If the original pressure was 100 torr, what is the new pressure?

A.	10 torr	B.	50 torr	C.	100 torr
D.	200 torr	E.	1000 torr		

4. A sample container of carbon monoxide occupies a volume of 435 mL at a pressure of 785 torr and a temperature of 298 K. What would its temperature be if the volume were changed to 265 mL at a pressure of 785 torr?

A.	182 K	B.	298 K	C.	387 K
D.	489 K	E.	538 K		

5. A sample of methane gas, $CH_4(g)$, occupies a volume of 60.3 L at a pressure of 469 torr and a temperature of 29.3°C. What would be its temperature at a pressure of 243 torr and volume of 60.3 L?

A.	-116.5°C	B.	15.2 °C	C.	15.5°C
D.	57.7°C	E.	310.6°C		

6. Assuming ideal behaviour, what is the density of argon gas at STP, in g/L?

A.	0.0176 g/L	B.	0.0250 g/L	C.	0.0561 g/L
D.	1.78 g/L	E.	181. g/L		

7. Lithium oxide is an effective absorber of carbon dioxide and can be used to purify air in confined areas such as space vehicles. What volume of carbon dioxide can be absorbed by 1.00 kg of lithium oxide at 25°C and 1.00 atm?

$Li_2O(aq) + CO_2(g) \rightarrow Li_2CO_3(s)$

A.	687 mL	B.	819 mL	C.	687 L
D.	819 L	E.	22.4 L		

8. Which of the following gases effuses most rapidly?

A.	nitrogen	B.	oxygen	C.	hydrogen chloride
D.	ammonia	E.	carbon monoxide		

9. Use the van der Waals equation for real gases to calculate the pressure exerted by 1.00 mole of ammonia at 27°C in a 750-mL container. ($a = 4.17\ L^2\cdot atm/mol^2$, $b = 0.0371$ L/mol)

A.	23.2 atm	B.	27.1 atm	C.	32.8 atm
D.	42.0 atm	E.	32.8 torr		

10. At very high pressures (~ 1000 atm), the measured pressure exerted by real gases is greater than that predicted by the ideal gas equation. This is mainly because

A. such high pressures cannot be accurately measured.
B. real gases will condense to form liquids at 1000 atm pressure.
C. gas phase collisions prevent molecules from colliding with the walls of the container.
D. of attractive intermolecular forces between gas molecules.
E. the volume occupied by the gas molecules themselves becomes significant.

11. A system receives 575 J of heat and delivers 425 J of work. Calculate the change in the internal energy, ΔE, of the system.

A. -150 J B. 150 J C. -1000 J
D. 1000 J E. 575 J

12. Calculate q when 28.6 g of water is heated from 22.0°C to 78.3°C.
A. 0.385 kJ B. 1.61 kJ C. 6.74 kJ
D. 9.37 kJ E. 1.61×10^3 kJ

13. Ethylene glycol, used as a coolant in automotive engines, has a specific heat capacity of 2.42 J/(g·K). Calculate q when 3.65 kg of ethylene glycol is cooled from 132°C to 85°C.
A. -1900 kJ B. -420 kJ C. -99 kJ
D. -0.42 kJ E. -4.2×10^{-6} kJ

14. Calcium hydroxide, which reacts with carbon dioxide to form calcium carbonate, was used by the ancient Romans as mortar in stone structures. The reaction for this process is
$Ca(OH)_2(s) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(g)$ $\Delta H = -69.1$ kJ

What is the enthalpy change if 3.8 mol of calcium carbonate is formed?
A. -18 kJ B. -69 kJ C. -73 kJ
D. -260 kJ E. None of these choices is correct.

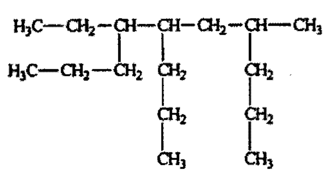
15. Use Hess's Law to calculate the enthalpy change for the reaction
$WO_3(s) + 3H_2(g) \rightarrow W(s) + 3H_2O(g)$
from the following data:
$2W(s) + 3O_2(g) \rightarrow 2WO_3(s)$ $\Delta H = -1685.4$ kJ
$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$ $\Delta H = -477.84$ kJ

A. 125.9 kJ B. 252.9 kJ C. 364.9 kJ
D. 1207.6 kJ E. None of these choices is correct.

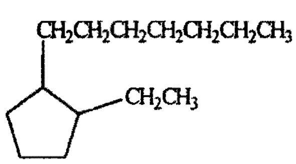
16. Which one of the following equations represents the formation reaction of $CH_3OH(l)$?
A. $C(g) + 2H_2(g) + ½O_2(g) \rightarrow CH_3OH(l)$ B. $C(g) + 4H(g) + O(g) \rightarrow CH_3OH(l)$
C. $C(graphite) + 4H(g) + O(g) \rightarrow CH_3OH(l)$ D. $C(diamond) + 4H(g) + O(g) \rightarrow CH_3OH(l)$
E. $C(graphite) + 2H_2(g) + ½O_2(g) \rightarrow CH_3OH(l)$

17. An important step in the synthesis of nitric acid is the conversion of ammonia to nitric oxide. $\Delta H°_f [NH_3(g)] = -45.9$ kJ/mol; $\Delta H°_f [NO(g)] = 90.3$ kJ/mol; $\Delta H°_f [H_2O(g)] = -241.8$ kJ/mol
$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$
Calculate $\Delta H°_{rxn}$ for this reaction.
A. -906.0 kJ B. -197.4 kJ C. -105.6 kJ
D. 197.4 kJ E. 906.0 kJ

18. Select the correct name for the following compound.
A. 2,4,5-tripropylheptane
B. 6-methyl-3,4-dipropylnonane
C. 4-ethyl-5,7-dipropyloctane
D. 5-ethyl-2,4-dipropyloctane
E. 4-ethyl-7-methyl-5-propyldecane

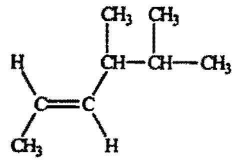


19. Select the correct name for the following compound.
A. *ortho*-ethylheptylcyclopentane
B. *meta*-ethylheptylcyclopentane
C. 1-ethyl-2-heptylcyclopentane
D. ethylcyclopentylheptane
E. *ortho*-ethylheptylbenzene

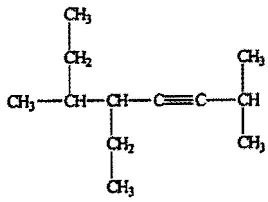


20. Select the correct name for the following compound.

A. *cis*-2,3-dimethyl-4-hexene
B. *trans*-2,3-dimethyl-4-hexene
C. *cis*-4,5-dimethyl-2-hexene
D. *trans*-4,5-dimethyl-2-hexene
E. *trans*-4,5-dimethyl-2-heptene

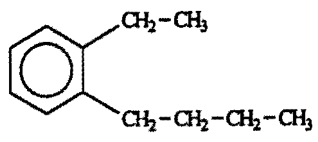


21. Select the correct name for the following compound.



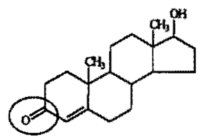
A. 4-ethyl-1,1,5-trimethyl-2-heptyne
B. 4,5-diethyl-1,1-dimethyl-2-heptyne
C. 5-ethyl-2,6-dimethyl-3-octene
D. 3-ethyl-3,7-dimethyl-5-octyne
E. 5-ethyl-2,6-dimethyl-3-octyne

22. Select the correct name for the following compound.



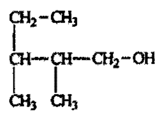
A. *ortho*-butylethylbenzene
B. *meta*-butylethylbenzene
C. *para*-butylethylbenzene
D. 1-butyl-2-ethylcyclohexene
E. 1-butyl-2-ethylcyclohexane

23. Testosterone is a male hormone. Identify the functional group circled.



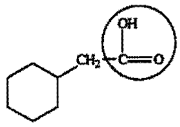
A. aldehyde
B. ketone
C. alcohol
D. ester
E. carboxyl

24. Select the correct name for the following compound.



A. 3-ethyl-2,3-dimethyl-1-propanol
B. 2,3,4-trimethyl-1-butanol
C. 2,3-dimethyl-1-pentanol
D. 3,4-dimethyl-5-pentanol
E. 2,3-dimethyl-1-pentanal

25. Identify the functional group circled.



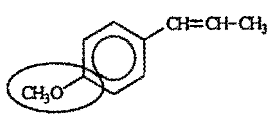
A. aldehyde
B. ketone
C. alcohol
D. ester
E. carboxylic acid

26. Putrescine is produced during the decay and protein breakdown of meats and is responsible for some of the odour found in them. Identify the functional group circled.

$H_2NCH_2CH_2CH_2CH_2NH_2$

A. aldehyde
B. ketone
C. amide
D. nitrile
E. amine

27. Anethole, a derivative of anise, is used in flavouring and as perfume in soap and toothpaste. Identify the functional group circled.



A. aldehyde
B. ketone
C. alcohol
D. ester
E. ether

28. Consider the following reaction

$8A(g) + 5B(g) \rightarrow 8C(g) + 6D(g)$

If [C] is increasing at the rate of 4.0 mol $L^{-1}s^{-1}$, at what rate is [B] changing?

A. -0.40 mol $L^{-1}s^{-1}$ B. -2.5 mol $L^{-1}s^{-1}$ C. -4.0 mol $L^{-1}s^{-1}$
D. -6.4 mol $L^{-1}s^{-1}$ E. None of these choices is correct, since its rate of change must be positive.

29. For the reaction

$3A(g) + 2B(g) \rightarrow 2C(g) + 2D(g)$

the following data was collected at constant temperature. Determine the correct rate law for this reaction.

Trial	Initial [A] (mol/L)	Initial [B] (mol/L)	Initial Rate (mol/(L·min))
1	0.200	0.100	6.00×10^{-2}
2	0.100	0.100	1.50×10^{-2}
3	0.200	0.200	1.20×10^{-1}
4	0.300	0.200	2.70×10^{-1}

A. Rate = $k[A][B]$ B. Rate = $k[A][B]^2$ C. Rate = $k[A]^3[B]^2$
D. Rate = $k[A]^{1.5}[B]$ E. Rate = $k[A]^2[B]$

30. When the reaction A → B + C is studied, a plot $1/[A]_t$ vs. time gives a straight line with a positive slope. What is the order of the reaction?

A. zero B. first C. second
D. third E. More information is needed to determine the order.

31. Which of the following sets of units could be appropriate for a zero-order rate constant?

A. s^{-1} B. L mol^{-1} s^{-1} C. L^2 mol^{-2} s^{-1}
D. L^3 mol^{-3} s^{-1} E. mol L^{-1} s^{-1}

32. A study of the decomposition reaction $3RS_2 \rightarrow 3R + 6S$ yields the following initial rate data

$[RS_2]$(mol L^{-1})	Rate (mol/(L·s))
0.150	0.0394
0.250	0.109
0.350	0.214
0.500	0.438

What is the rate constant for the reaction?

A. 0.0103 L $mol^{-1}s^{-1}$ B. 0.263 L $mol^{-1}s^{-1}$ C. 0.571 L $mol^{-1}s^{-1}$
D. 1.17 L $mol^{-1}s^{-1}$ E. 1.75 L $mol^{-1}s^{-1}$

33. When a chemical system is at equilibrium,

A. the concentrations of the reactants are equal to the concentrations of the products.
B. the concentrations of the reactants and products have reached constant values.
C. the forward and reverse reactions have stopped.
D. the reaction quotient, Q, has reached a maximum.
E. the reaction quotient, Q, has reached a minimum.

34. Write the mass-action expression, Q_c, for the following chemical reaction.

$NO(g) + \frac{1}{2}Br_2(g) \rightleftharpoons NOBr(g)$

A. $\frac{[NOBr]^2}{[NO]^2[Br_2]}$ B. $\frac{[NOBr]}{[NO]0.5[Br_2]}$ C. $\frac{[NO][Br_2]^{0.5}}{[NOBr]}$
D. $\frac{[NO]^2[Br_2]}{[NOBr]^2}$ E. $\frac{[NOBr]}{[NO][Br_2]^{0.5}}$

35. What is the mass-action expression, Q_c, for the following chemical reaction?

$PbO(s) + CO(g) \rightleftharpoons Pb(l) + CO_2(g)$

A. $\frac{[CO_2]}{[CO]}$ B. $\frac{[CO]}{[CO_2]}$ C. $\frac{[Pb][CO_2]}{[PbO][CO]}$

D. $\frac{[Pb][CO_2]}{[CO]}$ E. None of these expressions is correct.

36. At 500°C the equilibrium constant, K_p, is 4.00×10^{-4} for the equilibrium:

$2HCN(g) \rightleftharpoons H_2(g) + C_2N_2(g)$

What is K_p for the following reaction?

$H_2(g) + C_2N_2(g) \rightleftharpoons 2HCN(g)$

A. 2.00×10^{-4} B. -4.00×10^{-4} C. 1.25×10^{3}

D. 2.50×10^{3} E. 4.00×10^{4}

37. About half of the sodium carbonate produced is used in making glass products because it lowers the melting point of sand, the major component of glass. When sodium carbonate is added to water it hydrolyses according to the following reactions.

$CO_3^{2-}(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$ K_1

$HCO_3^-(aq) + H_2O(l) \rightleftharpoons H_2CO_3(aq) + OH^-(aq)$ K_2

These can be combined to yield

$CO_3^{2-}(aq) + 2H_2O(l) \rightleftharpoons H_2CO_3(aq) + 2OH^-(aq)$ K_3

What is the value of K_3?

A. $K_1 \times K_2$ B. $K_1 \div K_2$ C. $K_1 + K_2$

D. $K_1 - K_2$ E. $(K_1K_2)^2$

38. Consider the following two equilibria and their respective equilibrium constants:

(1) $NO(g) + ½O_2(g) \rightleftharpoons NO_2(g)$

(2) $2NO_2(g) \rightleftharpoons 2NO(g) + O_2(g)$

Which one of the following is the correct relationship between the equilibrium constants K_1 and K_2?

A. $K_2 = 2/K_1$ B. $K_2 = (1/K_1)^2$ C. $K_2 = -K_1/2$

D. $K_2 = 1/(2K_1)$ E. $K_2 = 1/(2K_1)^2$

39. The equilibrium constant, K_p, for the reaction

$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$

at 986°C is 0.63. A rigid cylinder at that temperature contains 1.2 atm of carbon monoxide, 0.20 atm of water vapor, 0.30 atm of carbon dioxide, and 0.27 atm of hydrogen. Is the system at equilibrium?

A. Yes.
B. No, the forward reaction must proceed to establish equilibrium.
C. No, the reverse reaction must proceed to establish equilibrium.
D. The volume of the container must be known before deciding.
E. The starting concentrations of all substances must be known before deciding.

40. A mixture 0.500 mole of carbon monoxide and 0.400 mole of bromine was placed into a rigid 1.00-L container and the system was allowed to come to equilibrium. The equilibrium concentration of $COBr_2$ was 0.233 *M*. What is the value of K_c for this reaction?

$CO(g) + Br_2(g) \rightleftharpoons COBr_2(g)$

A. 5.23 B. 1.22 C. 1.165

D. 0.858 E. 0.191

41. The reaction system

$POCl_3(g) \rightleftharpoons POCl(g) + Cl_2(g)$

is at equilibrium. Which of the following statements describes the behaviour of the system if the partial pressure of chlorine is reduced by 50%?

A. $POCl_3$ will be consumed as equilibrium is established.
B. POCl will be consumed as equilibrium is established.
C. Chlorine will be consumed as equilibrium is established.
D. The partial pressure of POCl will decrease while the partial pressure of Cl_2 increases as equilibrium is established.
E. The volume will have to decrease before equilibrium can be re-established.

42. The reaction system

$CS_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2S(g)$

is at equilibrium. Which of the following statements describes the behaviour of the system if the partial pressure of carbon disulfide is reduced?

A. As equilibrium is re-established, the partial pressure of carbon disulfide increases.
B. As equilibrium is re-established, the partial pressure of hydrogen decreases.
C. As equilibrium is re-established, the partial pressure of methane, CH_4, increases.
D. As equilibrium is re-established, the partial pressures of hydrogen and hydrogen sulfide decrease.
E. As equilibrium is re-established, all the partial pressures will increase.

43. The substance $NaNO_3$ is considered

A. a weak Arrhenius acid. B. a weak Arrhenius base.
C. a strong Arrhenius acid. D. a strong Arrhenius base.
E. a neutral compound.

44. What is the pH of a 0.20 *M* HCl solution?

A. < 0 B. 0.70 C. 1.61
D. 12.39 E. 13.30

45. What is the pH of a 0.050 *M* LiOH solution?

A. < 1.0 B. 1.30 C. 3.00
D. 11.00 E. 12.70

46. What is the $[OH^-]$ for a solution at 25°C that has $[H_3O^+] = 2.35 \times 10^{-3}$ *M*?

A. 4.26×10^{-5} *M* B. 2.35×10^{-11} *M* C. 4.26×10^{-12} *M*
D. 2.35×10^{-17} *M* E. None of these choices is correct.

47. Select the pair of substances in which an acid is listed followed by its conjugate base.

A. H^+, HCl B. NH_3, NH_4^+ C. HPO_4^{2-}, $H_2PO_4^-$
D. HCO_3^-, CO_3^{2-} E. CH_3COOH, $CH_3COOH_2^+$

48. Butyric acid is responsible for the odour in rancid butter. A solution of 0.25 *M* butyric acid has a pH of 2.71. What is the K_a for the acid?

A. 0.36 B. 2.4×10^{-2} C. 7.8×10^{-3}
D. 1.5×10^{-5} E. None of these choices is correct.

49. Aqueous solutions of phosphoric acid and sodium nitrite are combined, and the following equilibrium is established.

$H_3PO_4(aq) + NO_2^-(aq) \rightleftharpoons H_2PO_4^-(aq) + HNO_2(aq)$

The equilibrium constant K_c for this reaction is greater than one. Based on this information, which of the following statements is correct?

A. Phosphoric acid is a weaker acid than nitrous acid.
B. Nitrous acid is a weaker acid than water.

C. The nitrite anion is a weaker base than the dihydrogen phosphate anion.
D. The dihydrogen phosphate anion is a stronger acid than nitrous acid.
E. Phosphoric acid is a stronger acid than nitrous acid.

50. Which one of the following pairs is not a conjugate acid-base pair?

A.	H_2O/OH^-	B.	H_2O_2/HO_2^-	C.	OH^-/O^{2-}
D.	$H_2PO_4^-/HPO_4^{2-}$	E.	HCl/H^+		

Section B

Question 1

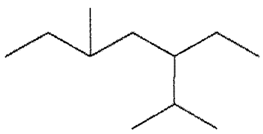
a) (i) Name any six classes of organic compounds. (4)

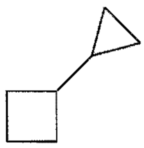
(ii) Give the functional group and a named example for each of the classes of compounds named in part (i) above. (6)

b) Write the structural formulas for all the constitutional isomers that have the following molecular formula. (9)

i. C_2H_7N
ii. C_3H_7Cl
iii. C_3H_8O

c) Expand the following bond line representations to show all the atoms including all the carbons and hydrogens. (6)

i. 

ii. 

Question 2

a) Nitrous oxide can be formed by thermal decomposition of ammonium nitrate.

$$NH_4NO_{3(s)} \longrightarrow N_2O_{(g)} + 2H_2O_{(g)}$$

What mass of ammonium nitrate would be required to produce 115 L of N_2O at 2800 Torr and 42°C (5)

b) (i) State Dalton's law of partial pressures. (2)

(ii) At 25°C, 0.300 moles of $CH_{4(g)}$, 0.200 mole of $H_{2(g)}$ and 0.400 mole of $N_{2(g)}$ are contained in a 10.0 L flask. Evaluate the partial pressure (in atm), of each of the components of the gaseous mixture in the flask, and the overall pressure in the flask. (8)

(iii) Suppose the temperature of the flask above is raised from 25°C to 75°C, evaluate the ratio of the total pressures in the flask at the two temperatures. (4)

(iv) Calculate the volume of 0.65 mole of an ideal gas at 499 Torr and 102°C (6)
(NB: use R = 0.0821 $L.atm.mol^{-1}K^{-1}$)

Question 3

a) For the standard enthalpy of formation of a substance, $\Delta H°_f$:

i. Define and state its S.I. units (2)

ii. Illustrate it with as example without giving its actual value (4)

iii. What is its value for an element in its thermochemical standard state? (2)

b) What does Hess's Law state? (2)

c) Given the following standard enthalpy changes of formation, calculate the standard enthalpy change of combustion of silane, SiH4 at 298 K:

$SiH_4(g)$ + $2O_2(g)$ $SiO_2(g)$ + $2H_2O(l)$

Substance	SiH4(g)	$SiO_2(g)$	$2H_2O(l)$
$\Delta H°_f$(KJ/mol)	+34.0	-910.9	-285.8

d) From the following equations and their corresponding standard enthalpy changes, calculate the $\Delta H°_{rxn}$, for the following reaction at 298 K. (6)

$$C(s) + 2H_2(g) \longrightarrow CH4(g)$$

Given: $\Delta H°$ (KJ)

$C(s)$	+	$O_2(g)$	$\longrightarrow$	$CO_2(g)$			-393.5
$H_2(g)$	+	$\frac{1}{2} O_2(g)$	$\longrightarrow$	$H_2O(l)$			-285.8
$CO_2(g)$	+	$2H_2O(l)$	$\longrightarrow$	$CH_4(g)$	+	$2O_2(g)$	+890.3

e) Given the following reaction:

$$2Ba(s) + O_2(g) \longrightarrow 2BaO(s) \qquad \Delta H^\circ = -1107.0 \text{ KJ}$$

How many KJ of heat are released when:

i. 4.62 g of $BaO(s)$ is produced (2)

ii. 13.94 g of $Ba(s)$ reacts completely with oxygen to form $BaO(s)$? (2)

f) A solution is made by mixing 15.3 mL of 0.25 M HCl and 17.0 mL of 0.33 M NaOH. Calculate the pH of this solution. (5)

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Department of Chemistry

Atomic Number		Atomic Weight
2	He	4.0026

1 H 1.0079																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.03	89 Ac 227.03															

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 146.92	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (234)	96 Cm (247)	97 Bk 247	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)