

SECTION A: Multiple Choice [60%]

Circle the letter for the one correct answer in each question.

The symbol for an ion containing **24 protons**, **27 neutrons**, and **21 electrons** is:

- a. $^{24}\text{Sb}^{3+}$
 - b. $^{51}\text{Co}^{3+}$
 - c. $^{51}\text{Cr}^{3+}$
 - d. $^{65}\text{Zn}^{2+}$
 - e. $^{58}\text{Zn}^{3+}$
2. Which one of the following statements is correct about NaHPO_4 ?
- a. Its name is sodium hydrogen phosphate
 - b. Its name is sodium hydrogen phosphite
 - c. Its name is sodium monohydrogen phosphate
 - d. Its name is sodium hydrogen phosphorus tetroxide
 - e. There is no compound with this formula.
3. Which one of the following classifications of elements is NOT CORRECT (is FALSE)?
- a. Sn ($Z = 50$) is a **transition metal**.
 - b. Ba ($Z = 56$) is an **alkaline earth metal**.
 - c. As ($Z = 33$) is a **metalloid**.
 - d. ($Z = 53$) is a **halogen**
 - e. Kr ($Z = 36$) is a **nonmetal**.

4. A compound of nitrogen and oxygen only, contains 36.85 % N by mass. Calculate the empirical formula.

a. NO

b.

c.

d. NO_2

e. N_2O_5

5. What mass of lithium nitrate, LiNO_3 , is needed to prepare 150 mL of a 0.0200 M $\text{LiNO}_3(\text{aq})$ solution?

a. 0.535 g

b. 0.207 g

c. 0.373 g

d. 0.621 g

e. 0.452 g

6. The element Engrium, En, has the following composition of isotopes:

^{147}En , 146.967 amu, 64.79 % abundant,

^{149}En , 148.964 amu, 26.12 % abundant,

^{150}En , 149.959 amu, 9.090 % abundant. What is the average atomic weight for En ?

a. 148.63 amu

b. 148.85 amu

c. 147.03 amu

d. 147.76 amu

e. 149.12 amu

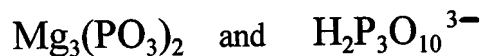
7. How many **H atoms** are present in 15.00 g of the compound $\text{Fe}_2(\text{HPO}_4)_3 \cdot 12\text{H}_2\text{O}$ (molar mass = 615.83 g/mol) ?

- a. 3.96×10^{23}
- b. 2.20×10^{23}
- c. 1.47×10^{22}
- d. 3.52×10^{23}
- e. 4.85×10^{23}

8. If 500 mL of a 0.250 M CaCl_2 (aq) solution is mixed with 200 mL of a 0.500 M HCl (aq) solution, what is the molarity (M) of the Cl^- ion in the resulting solution ?

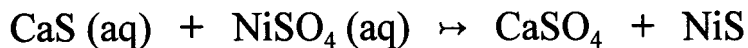
- a. 0.750 M
- b. 0.375 M
- c. 0.250 M
- d. 0.500 M
- e. 0.321 M

9. Calculate the **oxidation number** for the **P** atom in each of the two species:



- a. + 5 and + 6
- b. + 3 and + 5
- c. + 6 and + 15
- d. + 3 and + 4
- e. + 6 and + 5

10. Which are the **spectator ions** in the following equation (where some physical states have **not been included**) ?



- They are **all** spectator ions.
- $\text{Ca}^{2+} \text{ (aq)}$ and $\text{SO}_4^{2-} \text{ (aq)}$
- $\text{Ni}^{2+} \text{ (aq)}$ and $\text{S}^{2-} \text{ (aq)}$
- $\text{Ca}^{2+} \text{ (aq)}$ and $\text{S}^{2-} \text{ (aq)}$
- There are **no** spectator ions.

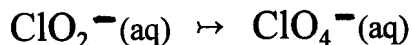
11. The non-balanced equation below,



can be correctly balanced with the **coefficients** (in this order):

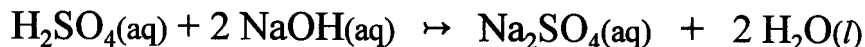
- 1, 13, 10, 5, 1
- 2, 25, 20, 11, 1
- 3, 39, 30, 16, 2
- 4, 49, 40, 22, 2
- 5, 66, 50, 25, 3

12. Balance the following half-reaction in **basic solution**, and indicate which one of the following statements is TRUE:

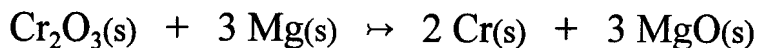


- There are 2 e^- on the left side (reactants).
- There are $2 \text{ ClO}_4^- \text{ (aq)}$ on the right side (products).
- There are $4 \text{ OH}^- \text{ (aq)}$ on the left side (reactants).
- There are $8 \text{ H}_2\text{O}(l)$ on the left side (reactants).
- There are $2 \text{ OH}^- \text{ (aq)}$ on the left side (reactants).

13. A dilute sulfuric acid solution, $\text{H}_2\text{SO}_4(\text{aq})$, of undetermined concentration, was titrated with standard $0.1495 \text{ M NaOH}(\text{aq})$ solution. If 10.00 mL of the $\text{H}_2\text{SO}_4(\text{aq})$ solution required 34.10 mL of the $\text{NaOH}(\text{aq})$ solution for neutralization, what is the molarity (M) of this sulfuric acid solution ?



- a. 0.300 M
b. 0.255 M
 0.315 M
d. 0.422 M
e. 0.500 M
14. Calculate the maximum mass (in g) of $\text{Cr}(\text{s})$ that can be produced by the reaction of 70.0 g of $\text{Cr}_2\text{O}_3(\text{s})$ {molar mass = 152.0 g/mol } and 31.0 g of $\text{Mg}(\text{s})$, according to the balanced equation below,



- a. 44.2 g
b. 101.0 g
c. 47.9 g
d. 23.9 g
e. 66.3 g
15. A 5.00 g sample of ozone gas, $\text{O}_3(\text{g})$, is contained in a 750 mL stainless-steel cylinder. If the temperature is at $-20.0 \text{ }^\circ\text{C}$, what is the gas pressure ?
- a. 3.50 atm
b. 4.01 atm
c. 3.15 atm
d. 1.96 atm
e. 2.88 atm

16. If 0.200 mol of $\text{H}_2(\text{g})$, 0.125 mol of $\text{He}(\text{g})$, and 0.100 mol of $\text{N}_2(\text{g})$ are together in the same 1.00 L container at 25 °C, what is the total gas pressure ?

- a. 7.95 atm
- b. 5.50 atm
- c. 10.4 atm
- d. 7.34 atm
- e. 9.03 atm

17. Calculate the energy of a photon of light having wavelength, $\lambda = 545 \text{ nm}$

- a. $3.65 \times 10^{-19} \text{ J}$
- b. $2.20 \times 10^5 \text{ J}$
- c. $6.06 \times 10^3 \text{ J}$
- d. $4.65 \times 10^{-15} \text{ J}$
- e. $2.20 \times 10^{15} \text{ J}$

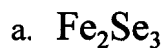
18. Indicate the **total number of electrons** in the same atom that can have **$n = 3$**

- a. 3
- b. 8
- c. 9
- d. 18
- e. 32

19. The number of **unpaired electrons** in the atoms, ${}_{23}\text{V}$ and ${}_{52}\text{Te}$ are, respectively:

- a. 5 and 6
- b. 3 and 4
- c. 3 and 2
- d. 5 and 4
- e. 3 and 6

20. The following electronic configurations are given for the cation (M^{3+}) and the anion (A^{2-})
 What is the formula for the compound formed from these ions?



21. Which one of the following sets of quantum numbers **could** describe the **highest energy** electron in the ground state configuration of the atom, ${}_{51}X$?

a. $n = 4, l = 3, m_l = 2, m_s = -\frac{1}{2}$

b. $n = 4, l = 2, m_l = -1, m_s = -\frac{1}{2}$

c. $n = 5, l = 1, m_l = -1, m_s = \frac{1}{2}$

d. $n = 5, l = 2, m_l = 1, m_s = \frac{1}{2}$

e. $n = 6, l = 1, m_l = 0, m_s = -\frac{1}{2}$

22. Which one of the following ionic compounds is expected to have the **highest** (most favorable) **lattice energy** ?

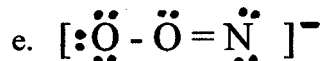
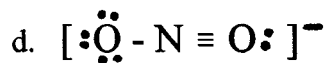
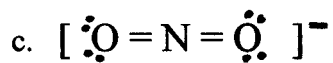
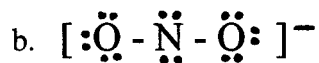
a.



d.



23. An **acceptable Lewis dot structure** for the nitrite anion, NO_2^- , is:



24. Which one of the following species **must have more than an octet (8) of electrons** around the central atom ?

a.

b.

c.

d. SO_3

e. BrCl_3

25. Which bond is expected to have the greatest **polarity** (is the **most polar** bond) ?

a.

b. As-Cl

c.

d. As-C

e. As-F

26. The geometry of the BrCl_4^- anion is best described as:

a. Tetrahedral

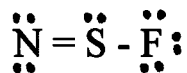
b. See saw molecule

c. T-shaped molecule

d. Trigonal bipyramidal

e. Square planar

27. Given the following Lewis dot structure, calculate the **Formal Charge** on the **N**, **S**, and **F** atoms, respectively:



- a.
- b. -1, +1, 0
- c. +1, -1, 0
- d. -1, +2, -1
- e. 0, +1, -1
28. The **bond angle**, $\angle \text{Cl-S-Cl}$, in SCl_4 is expected to be:
- a. Approximately 109.5°
- b. Approximately 90° , 120° , and 180°
- c. Exactly 90°
- d. Approximately 104°
- e. Slightly more than 130°
29. Which one of the following molecules is **polar** (has a **dipole moment**, $\mu \neq 0$) ?
- a.
- b. PF_5
- c. SbCl_3
- d. BF_3
- e.
30. What is the **hybridization** of the **I** atom in the ICl_4^+ cation ?
- a. $\text{sp}^3 \text{d}$
- b.
- c. sp^3
- d. $\text{sp}^3 \text{d}^2$
- e. sp

SECTION B (40%)

Answer each question in the space provided. If you require more space, use the back of the page. You may do your rough work on the back of the printed pages, but cross it out before submitting your paper. SHOW your work and reasoning in each question; answers without logical calculations will NOT be given credit.

A) NAME the following compounds:

$\text{Co}_2(\text{SO}_4)_3$ _____

P_4S_{10} _____

[2]

B) Write the chemical formula for each of the following compounds:

Zinc nitrate hexahydrate

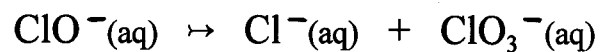
Hydrochloric acid _____

Dinitrogen pentoxide _____

[3]

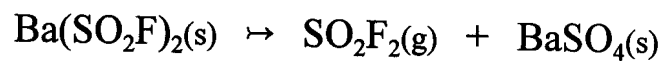
2 Convert 14.5 g/cm^3 into units of kg/m^3 , showing all the conversion factors. [3]

3. In **basic solution**, potassium hypochlorite (KClO) disproportionates into potassium chloride (KCl) and potassium chlorate (KClO₃). The non-balanced ionic equation is:



Using the method of half-reactions, **balance the ionic equation**. Then write the **full chemical equation** for this reaction. **[6]**

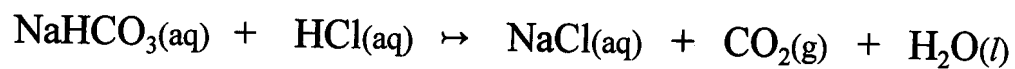
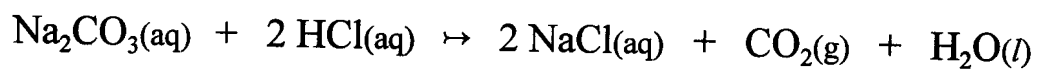
4. The thermal decomposition of barium fluorosulfate, $\text{Ba}(\text{SO}_2\text{F})_2$, is:



Calculate the **volume** of $\text{SO}_2\text{F}_2(\text{g})$, measured at **20°C and 700 Torr**, that can be prepared from **1.500 g** of $\text{Ba}(\text{SO}_2\text{F})_2$. The molar masses are: $\text{Ba}(\text{SO}_2\text{F})_2$, 303.45 g/mol, and SO_2F_2 , 102.06 g/mol.

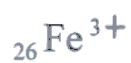
[5]

5. A 1.500 g solid sample is a mixture of sodium carbonate, Na_2CO_3 (molar mass = 105.99 g/mol), and sodium bicarbonate, NaHCO_3 (molar mass = 84.01 g/mol). That is: $\text{mass Na}_2\text{CO}_3 + \text{mass NaHCO}_3 = 1.500 \text{ g}$. After being dissolved in distilled water, this sample required 29.10 mL of 0.7500 M HCl(aq) solution for the complete neutralization. Find the mass of each component in this mixture.



[4]

6. (A) Using the **rare gas abbreviated forms**, write the ground state electronic configurations for the following atoms and ions:





[4]

(B) List the following elements in order of **decreasing electronegativity**:

Al, N, P, S

[1]

- 7 (i) Write/draw **three (3) different non-equivalent resonance structures for the OPCl_3** molecule, where **P** is the central atom.
- (ii) Then calculate the **Formal Charges** on each of the differently-bonded atoms.
- (iii) Finally, **select the most reasonable resonance structure for OPCl_3** (which may or may not be one of the structures you have drawn). [7]

8. For the chlorite anion, ClO_2^-

- (i) Write the Lewis dot structures (include reasonable resonance structures);
- (ii) Give the AB_xE_y formula and describe by **name** the overall geometry of the valence electron pairs;
- (iii) Describe by **name** the **geometry of the ion**;
- (iv) Describe the **bond angles** expected in the structure(s).

[5]

PERIODIC TABLE OF THE ELEMENTS

											18						
H 1.00794											2	He 4.00260					
3 Li 6.941	4 Be 9.01218											5 B 10.81	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.179
11 Na 22.9898	12 Mg 24.305											13 Al 26.9815	14	15	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.0983	20 Ca 40.08	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.8
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.22	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.6	53 I 126.9	54 Xe 131.29
55 Cs 132.905	56 Ba 137.33	71 Lu 174.967	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.207	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.908	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	103 Lr (260)	104 Rf (261)	105 Db (262)	106 Sg (263)	107 Bh (264)	108 Hs (265)	109 Mt (268)	110 Ds (269)	111 Uuu (272)	112 Uub (269)	114 Uuq	116 Uuh	118 Uuo			

Lanthanides:

57 La 138.906	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 161.930	68 Er 167.26	69 Tm 166.934	70 Yb 173.04
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Actinides:

89 Ac 227.028	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)
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