

# Atomic

5. Which of the following groups has the species correctly listed in order of increasing radius?

- (A)  $Mg^{2+}, Ca^{2+}, Ba^{2+}$  T  
 (B)  $K^+, Na^+, Li^+$  F  
 (C)  $Br^-, Cl^-, F^-$  F  
 (D) Na, Mg, Al F

6. Which of the following elements has the lowest electronegativity?

- (A) C  
 (B) K  
 (C) Al  
 (D) I

7. Choose the ion with the largest ionic radius.

- (A)  $F^-$   
 (B)  $Al^{3+}$   
 (C)  $K^+$   
 (D)  $I^-$

8. What is the name of the energy change when a gaseous atom, in the ground state, adds an electron?

- (A) ionization energy  
 (B) sublimation energy  
 (C) atomization energy  
 (D) electron affinity

9. The following ionization energies are reported for element X. (All the values are in kJ/mol.)

First	Second	Third	Fourth	Fifth
500	4,560	6,910	9,540	13,400

Based on the above information, the most likely identity of X is:

- (A) Mg  
 (B) Cl  
 (C) Al  
 (D) Na

10. In general, as the atomic numbers increase within a period, the atomic radius:

- (A) decreases  
 (B) increases  
 (C) first decreases and then increases  
 (D) does not change

# Stoich

5. Manganese, Mn, forms a number of oxides. A particular oxide is 63.2% Mn. What is the simplest formula for this oxide?

- (A) MnO  
 (B)  $Mn_2O_3$   
 (C)  $Mn_3O_4$   
 (D)  $MnO_2$

$$63.2/55 = 1.15$$

$$36.8/16 = 2.25$$

6. Vanadium forms a number of oxides. In which of the following oxides is the vanadium-to-oxygen mass ratio 2.39:1.00?

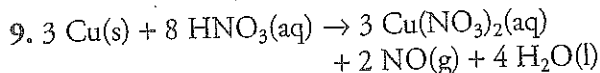
- (A) VO  
 (B)  $V_2O_3$   
 (C)  $V_3O_4$   
 (D)  $VO_2$

$$\frac{51}{16} = 3.19$$

$$\frac{102}{48} = 2.13$$

$$\frac{51}{32} = 1.59$$

$$\frac{153}{4} = 38.25$$

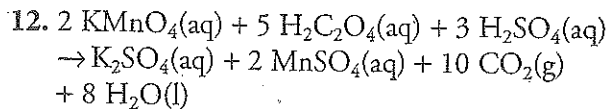


Copper metal reacts with nitric acid according to the above equation. A 0.30 mol sample of copper metal and 10.0 mL of 12 M nitric acid are mixed in a flask. How many moles of NO gas will form?

- (A) 0.060 mol  
 (B) 0.030 mol  
 (C) 0.010 mol  
 (D) 0.20 mol

$$3 \text{ Cu} + 8 \text{ HNO}_3$$

0.30	12	0
-3x	-8x	+2x
0		0.2



How many moles of  $MnSO_4$  are produced when 1.0 mol of  $KMnO_4$ , 5.0 mol of  $H_2C_2O_4$ , and 3.0 mol of  $H_2SO_4$  are mixed?

- (A) 4.0 mol  
 (B) 5.0 mol  
 (C) 2.0 mol  
 (D) 1.0 mol

$$2 \text{ K} + 5 \text{ H}_2 + 3 \text{ H}_2\text{SO}_4$$

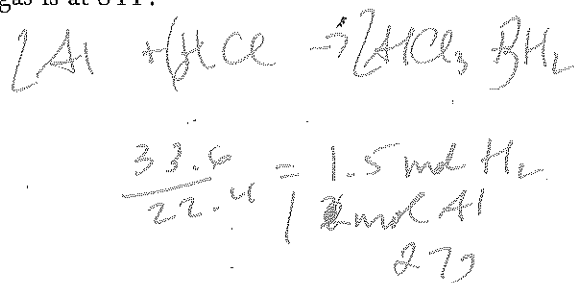
1	5	3
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# Gases

3. Two balloons are at the same temperature and pressure. One contains 14 g of nitrogen and the other contains 20.0 g of argon. Which of the following is true?
- (A) The density of the nitrogen sample is greater than the density of the argon sample. *F*
- (B) The average speed of the nitrogen molecules is greater than the average speed of the argon molecules. *T*
- (C) The average kinetic energy of the nitrogen molecules is greater than the average kinetic energy of the argon molecules. *F*
- (D) The volume of the nitrogen container is less than the volume of the argon container. *F*

6. Aluminum metal reacts with HCl to produce aluminum chloride and hydrogen gas. How many grams of aluminum metal must be added to an excess of HCl to produce 33.6 L of hydrogen gas, if the gas is at STP?

- (A) 18.0 g  
(B) 35.0 g  
(C) 27.0 g  
(D) 4.50 g



12. If a sample of  $\text{CH}_4$  effuses at a rate of 9.0 mol per hour at  $35^\circ\text{C}$ , which of the gases below will effuse at approximately twice the rate under the same conditions?

- (A) CO  
(B) He  
(C)  $\text{O}_2$   
(D)  $\text{F}_2$

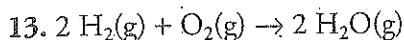
$\frac{9}{18} = \sqrt{\frac{16 \times}{16}}$

14. Choose the gas that probably shows the greatest deviation from ideal gas behavior.

- (A) He  
(B)  $\text{O}_2$   
(C)  $\text{SF}_4$   
(D)  $\text{SiH}_4$

# Thermo

1. Which of the following is the minimum energy required to initiate a reaction?
- (A) free energy  
(B) lattice energy  
(C) kinetic energy  
(D) activation energy
2. What is the minimum energy required to force a nonspontaneous reaction to occur?
- (A) free energy  
(B) lattice energy  
(C) kinetic energy  
(D) activation energy
3. The average \_\_\_\_\_ is the same for any ideal gas at a given temperature.
- (A) free energy  
(B) lattice energy  
(C) kinetic energy  
(D) activation energy
4. What is the energy released when the gaseous ions combine to form an ionic solid?
- (A) free energy  
(B) lattice energy  
(C) kinetic energy  
(D) activation energy



From the table below, determine the enthalpy change for the above reaction.

BOND	AVERAGE BOND ENERGY (kJ/mol)
H-H	436
O=O	499
H-O	464

- (A) 0 kJ  
(B) 485 kJ  
(C) -485 kJ  
(D) 464 kJ

$2(436) + 4(464)$   
 $499$   
 $1371 - 1856 = -485$

# Bonding

3. Which of the following does not have one or more  $\pi$  bonds?

- (A)  $\text{H}_2\text{O}$
- (B)  $\text{HNO}_3$
- (C)  $\text{O}_2$
- (D)  $\text{N}_2$

4. Which of the following is polar?

- (A)  $\text{SF}_4$
- (B)  $\text{XeF}_4$
- (C)  $\text{CF}_4$
- (D)  $\text{SbF}_5$

5. Resonance structures are necessary to describe the bonding in which of the following?

- (A)  $\text{H}_2\text{O}$
- (B)  $\text{ClF}_3$
- (C)  $\text{HNO}_3$
- (D)  $\text{CH}_4$

For questions 6. and 7, pick the best choice from the following:

- (A) ionic bonds
- (B) hybrid orbitals
- (C) resonance structures
- (D) van der Waals attractions

6. An explanation of the equivalent bond lengths of the nitrite ion is:

7. Most organic substances have low melting points. This may be because, in most cases, the intermolecular forces are:

8. Which of the following has more than one unshared pair of valence electrons on the central atom?

- (A)  $\text{BrF}_5$
- (B)  $\text{NF}_3$
- (C)  $\text{IF}_7$
- (D)  $\text{ClF}_3$

# Atomic again

1. Which of the following represents the electron arrangement for the least reactive element?

- (A)  $1s \uparrow 2s \uparrow \downarrow$
- (B)  $1s \uparrow \downarrow 2s \uparrow$
- (C)  $[\text{Kr}] 5s \uparrow \downarrow 4d \uparrow \uparrow \_ \_ \_$
- (D)  $1s \uparrow \downarrow 2s \uparrow \downarrow 2p \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$

2. Which of the following might refer to a transition element?

- (A)  $1s \uparrow 2s \uparrow \downarrow$
- (B)  $1s \uparrow \downarrow 2s \uparrow$
- (C)  $[\text{Kr}] 5s \uparrow \downarrow 4d \uparrow \uparrow \_ \_ \_$
- (D)  $1s \uparrow \downarrow 2s \uparrow \downarrow 2p \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$

3. Which of the following electron arrangements refers to the most chemically reactive element?

- (A)  $1s \uparrow 2s \uparrow \downarrow$
- (B)  $1s \uparrow \downarrow 2s \uparrow$
- (C)  $[\text{Kr}] 5s \uparrow \downarrow 4d \uparrow \uparrow \_ \_ \_$
- (D)  $1s \uparrow \downarrow 2s \uparrow \downarrow 2p \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$

4. Which of the following electron arrangements represents an atom in an excited state?

- (A)  $1s \uparrow 2s \uparrow \downarrow$
- (B)  $1s \uparrow \downarrow 2s \uparrow$
- (C)  $[\text{Kr}] 5s \uparrow \downarrow 4d \uparrow \uparrow \_ \_ \_$
- (D)  $1s \uparrow \downarrow 2s \uparrow \downarrow 2p \uparrow \downarrow \uparrow \downarrow \uparrow \downarrow$

5. The ground-state configuration of  $\text{Fe}^{2+}$  is which of the following?

- (A)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
- (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$
- (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
- (D)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^8 4s^2$

# Atomic again cont

IMF

6. Which of the following contains only atoms that are diamagnetic in their ground state?

- (A) Kr, Ca, and P
- (B) Ne, Be, and Zn
- (C) Ar, K, and Ba
- (D) He, Sr, and C

7. Which of the following is the electron configuration of a halogen?

- (A)  $1s^2 1p^6 2s^2 2p^3$
- (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$
- (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
- (D)  $1s^2 2s^2 2p^5$

8. Which of the following is a possible configuration for a transition metal atom?

- (A)  $1s^2 1p^6 2s^2 2p^3$
- (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$
- (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
- (D)  $1s^2 2s^2 2p^5$

9. Which of the following electron configurations is not possible?

- (A)  $1s^2 1p^6 2s^2 2p^3$
- (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$
- (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
- (D)  $1s^2 2s^2 2p^5$

10. This is a possible configuration of a transition metal ion.

- (A)  $1s^2 1p^6 2s^2 2p^3$
- (B)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^1$
- (C)  $1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$
- (D)  $1s^2 2s^2 2p^5$

1. Which of the following best describes Fe(s)?

- (A) composed of macromolecules held together by strong bonds
- (B) composed of atoms held together by delocalized electrons
- (C) composed of positive and negative ions held together by electrostatic attractions
- (D) composed of molecules held together by intermolecular dipole-dipole interactions

2. The best description of the interactions in  $KNO_3(s)$  is which of the following?

- (A) composed of macromolecules held together by strong bonds
- (B) composed of atoms held together by delocalized electrons
- (C) composed of positive and negative ions held together by electrostatic attractions
- (D) composed of molecules held together by intermolecular dipole-dipole interactions

3. Sand is primarily  $SiO_2(s)$ . Which of the following best describes the interactions inside a grain of sand?

- (A) composed of macromolecules held together by strong bonds
- (B) composed of atoms held together by delocalized electrons
- (C) composed of positive and negative ions held together by electrostatic attractions
- (D) composed of molecules held together by intermolecular dipole-dipole interactions

4. At sufficiently low temperatures, it is possible to form  $HCl(s)$ . What best describes the interactions in this solid?

- (A) composed of macromolecules held together by strong bonds
- (B) composed of atoms held together by delocalized electrons
- (C) composed of positive and negative ions held together by electrostatic attractions
- (D) composed of molecules held together by intermolecular dipole-dipole interactions

# IMF cont

5. Which of the following best describes diamond, C(s)?

- (A) an ionic solid
- (B) a metallic solid
- (C) a molecular solid containing polar molecules
- (D) a covalent network solid

6. What type of solid is solid sulfur dioxide, SO<sub>2</sub>(s)?

- (A) an ionic solid
- (B) a metallic solid
- (C) a molecular solid containing polar molecules
- (D) a covalent network solid

10. The only substance listed below that contains ionic,  $\sigma$ , and  $\pi$  bonds is:

- (A) Na<sub>2</sub>CO<sub>3</sub>
- (B) HClO<sub>2</sub>
- (C) H<sub>2</sub>O
- (D) NaCl



$$7 + 2(6) = 19 + 1 = 20$$

ClO<sub>2</sub><sup>-</sup>

11. The electron pairs point toward the corners of which geometrical shape for a molecule with sp<sup>2</sup> hybrid orbitals?

- (A) trigonal planar
- (B) octahedron
- (C) trigonal bipyramid
- (D) trigonal pyramid

14. Which of the following molecules is the least polar?

- (A) PH<sub>3</sub>
- (B) CH<sub>4</sub>
- (C) H<sub>2</sub>O
- (D) NO<sub>2</sub>

15. Which of the following molecules is the most polar?

- (A) NH<sub>3</sub>
- (B) N<sub>2</sub>
- (C) CH<sub>3</sub>I
- (D) BF<sub>3</sub>