Multiple Choice Questions

Questions 1-5: The set of lettered choices below is a list of regions of the electromagnetic spectrum. Select the lettered choice that best fits each statement. A choice may be used once, more than once, or not at all.

(A) infrared
(B) microwaves
(C) ultraviolet
(D) visible
(E) x-rays

1. Radiation in this region has the highest energy of those listed. E
2. Radiation in this region is used to analyze colored solutions. D
3. Radiation in this region passes through ordinary glass but can be blocked by treated glass. B
4. Radiation in this region is used in the analysis of metallic crystal structures. E
5. Radiation in this region is used as a detection beam across doorways and windows. A

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6. Which is a list of elements in order of **increasing** first ionization energy?
   (A) Cl, P, Si
   (B) N, P, As
   (C) Sr, Ca, Mg
   (D) Cl, Br, I
   (E) F, Ne, Na

7. The overall electron configuration of the sulfide ion is most similar to (isoelectronic with) the electron configuration of the
   (A) oxide ion
   (B) chlorine atom
   (C) oxygen atom
   (D) sodium ion
   (E) potassium ion

8. Which describes the behavior of potassium metal during a chemical reaction?

I. Neutral atoms become ions with a 1+ charge.
II. Neutral atoms take on protons.
III. Neutral atoms become ions with a corresponding increase in radius.

(A) I only
(B) I and II only
(C) III only
(D) II and III only
(E) I, II, and III

9. Of the elements listed, which is the heaviest element whose atoms have more *s* electrons than *p* electrons?

(A) $_5$B
(B) $_7$N
(C) $_9$F
(D) $_{12}$Mg
(E) $_{13}$Al

10. The value of Planck's constant is 6.63×10^{-34} J sec. The velocity of light is 3.0×10^8 m sec^{-1}. Which value in joules is closest to the energy of a photon with frequency of 8.0×10^{15} sec^{-1}?

(A) 1×10^{-20}
(B) 5×10^{-20}
(C) 5×10^{-19}
(D) 1×10^{-18}
(E) 5×10^{-18}

11. The value of Planck's constant is 6.63×10^{-34} J sec. The speed of light is 3.0×10^{17} nm sec^{-1}. Which value is closest to the wave length in nanometers of a quantum of light with frequency of 6×10^{15} sec^{-1}?

(A) 10
(B) 25
(C) 50
(D) 75
(E) 100

12. What is the number of half-filled orbitals in an atom of phosphorus?

(A) none
(B) one
(C) three
(D) five
(E) seven

13. Which description of electron configuration applies to atoms of potassium, chromium and copper?

(A) only one half-filled orbital
(B) only one filled sublevel
(C) only three half-filled orbitals
(D) only nine filled orbitals
(E) only five filled sublevels

Remember Cr & Cu are exceptions they fill 4s¹ then 3d then 4s²

14. How does the electron structure of a phosphorus atom differ from that of a phosphide ion?

I. The phosphide ion has more electrons.
II. The phosphorus atom has more unpaired electrons.
III. The phosphide ion has more kernel (core) electrons.

(A) I only
(B) I and II only
(C) I and III only
(D) II and III only
(E) I, II, and III

15. What is the number of electrons in an atom of $_{23}V$ that have an ℓ quantum number of 2?

(A) 2
(B) 3
(C) 6
(D) 10
(E) 12

16. The electron configuration of atoms of germanium, $_{32}Ge$, is shown below:

[Ar core] $3d^{10}\ 4s^2\ 4p^2$

This element is known to form more than one oxide. Which pair of formulas includes the two most likely formulas for these oxides?

(A) GeO and GeO_2
(B) GeO_2 and Ge_2O_7
(C) Ge_2O_3 and GeO_2
(D) GeO and Ge_2O_3
(E) Ge_2O_3 and Ge_2O_7

17. The most abundant isotopes of hydrogen and oxygen are $^{1}_{1}H$, $^{2}_{1}H$, $^{16}_{8}O$, and $^{17}_{8}O$, respectively. Using these isotopes only, what is the number of different possible values for the molar mass of water in grams?

(A) 2
(B) 3
(C) 4
(D) 6
(E) 8

18. Which set of formulas or symbols best illustrates the Law of Multiple Proportions?

(A) $^{12}_{6}C$ and $^{14}_{6}C$
(B) $^{14}_{6}C$ and $^{14}_{7}N$
(C) CO and CO_2
(D) CH_4 and CCl_4
(E) C_2H_5OH and CH_3OCH_3

19. All of the following can be inferred from the Lewis dot diagram of a neutral atom below EXCEPT

(A) X belongs to the same family as sulfur.
(B) X has two half filled p-orbitals.
(C) X has at least ten kernel (core) electrons.
(D) X can accept two electrons to become an ion with a charge of 2^-.
(E) X has at least four electrons with ℓ quantum number of 1.

20. Consider the set of quantum numbers: 3, 2, -1, $-\frac{1}{2}$

Which set of quantum numbers represents an electron with the same energy but different orientation in space as the electron represented above?

(A) 3, 2, -1, $+\frac{1}{2}$
(B) 3, 1, -1, $-\frac{1}{2}$
(C) 3, 2, 0, $+\frac{1}{2}$
(D) 2, 1, 0, $+\frac{1}{2}$
(E) 2, 2, -1, $-\frac{1}{2}$

21. What is the number of filled orbitals in a ground state atom of manganese, $_{25}Mn$?

(A) 7
(B) 10
(C) 12
(D) 13
(E) 15

22. Which gives a list of species with the same electron configuration; that is, species that are isoelectronic?

(A) Mg, Ca, Sr
(B) Mg^{2+}, Ca^{2+}, Sr^{2+}
(C) F^-, S^{2-}, As^{3-}
(D) Fe, Co, Ni
(E) S^{2-}, Cl^-, K^+

23. Which color in the visible spectrum is associated with the lowest frequency?

(A) blue
(B) green
(C) red
(D) violet
(E) yellow

24. According to quantum mechanics, what is the maximum number of electrons that can occupy the third energy level in a ground state atom?

(A) 2
(B) 4
(C) 8
(D) 18
(E) 32

25. Which pair of atoms represents nuclei that have the same number of neutrons?

(A) ^{56}Co and ^{58}Co
(B) ^{57}Mn and ^{57}Fe
(C) ^{58}Ni and ^{57}Fe
(D) ^{58}Ni and ^{57}Co
(E) ^{59}Ni and ^{56}Fe

Multiple Choice Questions

1. Which of these alkaline earth metal oxides has the greatest percent by mass of oxygen?

(A) barium oxide
(B) beryllium oxide
(C) calcium oxide
(D) magnesium oxide
(E) strontium oxide

2. Which expression gives percent by mass of carbon in oxalic acid, $H_2C_2O_4 \cdot 2H_2O$?

(A) $\frac{2}{14} \times 100$

(B) $\frac{12}{90} \times 100$

(C) $\frac{24}{66} \times 100$

(D) $\frac{24}{90} \times 100$

(E) $\frac{24}{126} \times 100$

3. Which oxides of manganese, Mn, have percent by mass of manganese that is greater than 50%?

I. MnO
II. MnO_2
III. Mn_2O_3

(A) II only
(B) III only
(C) I and III only
(D) II and III only
(E) I, II, and III

4. Which describes the resulting system when 0.40 moles of $Na_2CO_{3(s)}$ is added to 0.50 liters of 0.60 molar $CuCl_2$ solution?

(A) A blue precipitate forms; excess CO_3^{2-} is found in solution.
(B) A blue precipitate forms; excess Cu^{2+} is found in solution.
(C) A blue precipitate forms; no excess reactants are found in solution.
(D) A nearly colorless homogeneous system forms; excess CO_3^{2-} is found in solution.
(E) A nearly colorless homogeneous system forms; excess Cu^{2+} is found in solution.

5. Which pair of samples contains the same number of oxygen atoms in each compound?

(A) 0.10 mol Al_2O_3 and 0.50 mol BaO

(B) 0.20 mol Cl_2O and 0.10 mol HClO

(C) 0.20 mol SnO and 0.20 mol SnO_2

(D) 0.10 mol Na_2O and 0.10 mol Na_2SO_4

(E) 0.20 mol $Ca(OH)_2$ and 0.10 mol $H_2C_2O_4$

6. Consider the reaction

$$2Na_3PO_{4(aq)} + 3ZnCl_{2(aq)} \rightarrow Zn_3(PO_4)_{2(s)} + 6\ NaCl_{(aq)}$$

A precipitate is formed when 0.20 moles of sodium phosphate, Na_3PO_4, is mixed with 0.80 moles of zinc chloride, $ZnCl_2$, in water solution. Which lists the ions in water solution after the reaction occurs, in order of increasing concentration?

(A) Na^+, Cl^-, Zn^{2+}, PO_4^{3-}

(B) Zn^{2+}, PO_4^{3-}, Na^+, Cl^-

(C) PO_4^{3-}, Zn^{2+}, Na^+, Cl^-

(D) PO_4^{3-}, Zn^{2+}, Cl^-, Na^+

(E) Zn^{2+}, PO_4^{3-}, Cl^-, Na^+

7. Consider the reaction

$$2ZnS_{(s)} + 3O_{2(g)} \rightarrow 2ZnO_{(s)} + 2SO_{2(g)}$$

Which value is closest to the mass of $ZnO_{(s)}$ produced when 50.0 g $ZnS_{(s)}$ is heated in an open vessel until no further weight loss is observed?

(molar masses: O_2 – 32 g, SO_2 – 64 g, ZnO – 81 g, ZnS – 97 g)

(A) 25 grams

(B) 40 grams

(C) 50 grams

(D) 60 grams

(E) 75 grams

8. Consider the reaction

$$2Al_{(s)} + 3Cl_{2(g)} \rightarrow 2AlCl_{3(s)}$$

Which expression gives the volume of Cl_2 consumed, measured at 1 atm and 273 K, when 25.0 g Al reacts completely with Cl_2 according to the above equation?

(A) $25.0 \times \frac{3}{2} \times \frac{22.4}{2}$

(B) $\frac{25.0}{22.4} \times \frac{3}{2} \times \frac{22.4}{2}$

(C) $25.0 \times \frac{27}{1} \times \frac{3}{2} \times \frac{22.4}{1}$

(D) $25.0 \times \frac{1}{27} \times \frac{3}{2} \times \frac{22.4}{1}$

(E) $25.0 \times \frac{1}{27} \times \frac{2}{3} \times \frac{22.4}{1}$

9. Which sample contains the greatest number of nitrogen atoms? (All measurements taken at 1 atm and 273 K.)

(A) 0.20 mol $N_2O_{4(g)}$

(B) 0.40 mol $N_{2(g)}$

(C) 40. L $NO_{2(g)}$

(D) 40. g $NH_{3(g)}$

(E) 80. g $N_2O_{4(g)}$

10. $$C_3H_{8(g)} + 5O_{2(g)} \rightarrow 3CO_{2(g)} + 4H_2O_{(g)}$$

Propane gas, $C_3H_{8(g)}$, burns according to the equation above. A mixture containing 0.030 moles of $C_3H_{8(g)}$ and 0.200 moles of $O_{2(g)}$ is placed in a rigid container and its pressure measured. The mixture is ignited. Which describes the contents of the container after maximum reaction has occurred and the system returned to its original temperature?

(A) 0.050 mol $O_{2(g)}$ remains unreacted and the pressure has increased.

(B) 0.050 mol $O_{2(g)}$ remains unreacted and the pressure has decreased.

(C) 0.170 mol $O_{2(g)}$ remains unreacted and the pressure has decreased.

(D) 0.020 mol $C_3H_{8(g)}$ remains unreacted and the pressure has decreased.

(E) 0.020 mol $C_3H_{8(g)}$ remains unreacted and the pressure has increased.

11. When the equation for the reaction below is balanced using smallest whole numbers, which gives a correct description of the information in the equation?

$$..?..\,Sc(NO_3)_3 + ..?..\,NaOH \rightarrow ..?..\,Sc(OH)_3 + ..?..\,NaNO_3$$

I. The number of ions represented is 20.
II. The number of atoms represented is 22.
III. The sum of the coefficients is 8.

(A) II only
(B) III only
(C) I and II only
(D) II and III only
(E) I, II, and III

12. An unidentified compound is reported to contain 77.5% manganese and 22.5% oxygen by mass. Which set of values when substituted for x and y gives the best representation of the empirical formula for the unidentified compound?

$$Mn_xO_y$$

(A) $\frac{77.5}{54.9}$ and $\frac{16.0}{22.5}$

(B) $\frac{77.5}{54.9}$ and $\frac{22.5}{16.0}$

(C) $\frac{54.9}{22.5}$ and $\frac{16.0}{77.5}$

(D) $\frac{54.9}{77.5}$ and $\frac{16.0}{22.5}$

(E) $\frac{54.9}{22.5}$ and $\frac{16.0}{77.5}$

13. What minimum volume of 0.200 M Na_2CO_3 is needed to precipitate all the Sr^{2+} from 25.0 mL of 0.100 M $Sr(NO_3)_2$?

(A) 6.25 mL
(B) 12.5 mL
(C) 25 mL
(D) 50 mL
(E) 100 mL

14. $$Cu_{(s)} + 4HNO_{3(aq,conc)} \rightarrow 2NO_{2(g)} + Cu(NO_3)_{2(aq)} + 2H_2O$$

What volume of $NO_{2(g)}$ measured at 1 atm and 273 K can be produced by the reaction of 0.750 mol copper with excess concentrated nitric acid according to the equation above?

(A) 11.2 liters
(B) 22.4 liters
(C) 33.6 liters
(D) 44.8 liters
(E) 67.2 liters

15. $$Al^{3+} + 3e^- \rightarrow Al^0$$

In the half-reaction shown above, the term $3e^-$ represents

(A) $3 \times 96{,}500$ electrons
(B) $3 \times 6.02 \times 10^{23}$ electrons
(C) $3 \times 6.02 \times 10^{23}$ coulombs
(D) $\frac{3}{27} \times 96{,}500$ electrons
(E) $\frac{3}{27} \times 6.02 \times 10^{23}$ electrons

16. Consider the combustion of ethane as shown in the equation below.

$$2C_2H_{6(g)} + 7O_{2(g)} \rightarrow 4CO_{2(g)} + 6H_2O_{(g)}$$

What quantity of reactant remains after ignition of a mixture that contains 0.60 moles of C_2H_6 mixed with 2.50 moles of O_2? (Assume maximum reaction according to the equation above.)

(A) 0.20 mol O_2
(B) 0.40 mol O_2
(C) 1.90 mol O_2
(D) 0.20 mol C_2H_6
(E) 0.30 mol C_2H_6

Questions 17-19: A mixture is prepared by adding 100. mL of 0.10 *M* Na_2CrO_4 to 100. mL of 0.10 *M* $AgNO_3$. A precipitate forms in this mixture. The precipitate is separated from the mixture by filtration.

17. What is the concentration of Na^+ in the reaction mixture after filtration?

(A) 0.050 *M*
(B) 0.10 *M*
(C) 0.15 *M*
(D) 0.20 *M*
(E) 0.40 *M*

18. What quantity of solid product is produced?

(A) 0.0025 mol
(B) 0.0050 mol
(C) 0.010 mol
(D) 0.015 mol
(E) 0.020 mol

19. Which describes the changes in concentration of the spectator ions, Na^+ and NO_3^- in the reaction mixture as the reaction occurs in the beaker containing $AgNO_{3(aq)}$?

	$[Na^+]$	$[NO_3^-]$
(A)	increases	remains the same
(B)	remains the same	decreases
(C)	remains the same	remains the same
(D)	increases	decreases
(E)	decreases	decreases

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20. $$2Al_{(s)} + 3S_{(s)} \rightarrow Al_2S_{3(s)}$$

What mass of Al_2S_3 is produced when 1.50 moles of aluminum reacts with excess sulfur according to the equation above?

(A) 40.5 g
(B) 48.0 g
(C) 61.5 g
(D) 75.0 g
(E) 113 g

21. When 0.60 mol ZnS was roasted in pure oxygen, 0.40 mol SO_2 was collected. Which best describes the contents of the solid phase remaining in the crucible?

(A) no excess ZnS; 0.60 mol ZnO
(B) no excess ZnS; 0.30 mol ZnO
(C) 0.20 mol excess ZnS; 0.30 mol ZnO
(D) 0.20 mol excess ZnS; 0.40 mol ZnO
(E) 0.30 mol excess ZnS; 0.40 mol ZnO

22. The mass of element X found in 1.0 mole each of four different compounds is 28 g, 42 g, 56 g and 84 g, respectively. Which of the following is a possible atomic mass for element X?

(A) 14
(B) 28
(C) 35
(D) 42
(E) 49

23. Which value is closest to the volume of $O_{2(g)}$ measured at STP that could be produced when 0.20 mol $KClO_{3(s)}$ is heated according to the equation below?

$$2KClO_{3(s)} \rightarrow 2KCl_{(s)} + 3O_{2(g)}$$

(A) 4.5 L
(B) 6.7 L
(C) 7.5 L
(D) 15. L
(E) 34. L

24. How many moles of $KCl_{(s)}$ should be added to 0.500 liters of 0.20 M $CrCl_3$ solution to increase the chloride concentration to 1.00 M? (Assume no change in volume.)

(A) 0.20
(B) 0.40
(C) 0.50
(D) 0.60
(E) 0.80

25. Epsom salt, $MgSO_4 \cdot 7H_2O$, (molar mass: 246 g) can be dehydrated by heating in an open crucible. Which value is closest to the fraction of the mass of salt in the crucible lost when the crucible is heated to constant weight?

(A) $\frac{1}{8}$
(B) $\frac{1}{7}$
(C) $\frac{1}{4}$
(D) $\frac{1}{3}$
(E) $\frac{1}{2}$