

1. What is the final concentration of  $\text{Cl}^-$  ion when 250 mL of 0.20 M  $\text{CaCl}_2$  solution is mixed with 250 mL of 0.40 M  $\text{KCl}$  solution? (Assume additive volumes.)
- 26
- (A) 0.10 M  
(B) 0.20 M  
(C) 0.30 M  
(D) 0.40 M  
(E) 0.60 M
2. What volume of water should be added to 0.40 L of 6.0 M  $\text{H}_2\text{SO}_4$  solution to produce a solution that is 2.0 M  $\text{H}_2\text{SO}_4$ ?
- 27
- (A) 0.40 L  
(B) 0.80 L  
(C) 1.2 L  
(D) 1.6 L  
(E) 2.4 L
3. What piece of laboratory apparatus is least likely to be used to prepare a quantity of standard 1.00 M  $\text{BaCl}_2$  using solid  $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$  and distilled water?
- 28
- (A) funnel  
(B) crucible  
(C) thermometer  
(D) volumetric flask  
(E) laboratory balance
4. What is the percent methanol by mass in a solution that contains 20 grams of methanol,  $\text{CH}_3\text{OH}$ , in 30 grams of water?
- 29
- (A) 20%  
(B) 33%  
(C) 40%  
(D) 60%  
(E) 67%

5  
30

8. A standard solution of sodium hydroxide can be used in a titration experiment to determine the formula mass of a solid acid. A common mistake in such a titration experiment is the failure to rinse the buret with the standard solution after the final water rinse but before measurements of the volume of the standard solution are taken. This mistake accounts for which of the following results?

- I. The volume of the standard solution used in the titration reaction is reported too small.
- II. The volume of the solute used to dissolve the unknown acid is reported too small.
- III. The number of moles of unknown acid used in the titration reaction is reported too large.

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

6  
31

10. Which substance is most likely to be found in an aqueous solution that is both saturated and dilute at room temperature?

- (A) sucrose
- (B) silver acetate
- (C) sodium chloride
- (D) ammonium carbonate
- (E) potassium hydroxide

7  
32

11. Which substance is least likely to be found in an aqueous solution that is concentrated?

- (A) sodium phosphate
- (B) hydrogen bromide
- (C) magnesium hydroxide
- (D) aluminum chloride
- (E) ammonium nitrate

8  
33

12. The level of arsenic permitted in drinking water is 0.050 ppm (parts per million). Which of the following is another way to express that same concentration?

- ~~(A)~~ 0.050 mg As/milliliter H<sub>2</sub>O
- ~~(B)~~ 0.050 mg As/liter H<sub>2</sub>O
- ~~(C)~~ 0.050 g As/million liters H<sub>2</sub>O
- ~~(D)~~ 0.050 mg As/million liters H<sub>2</sub>O
- ~~(E)~~ 0.050 mg As/million grams H<sub>2</sub>O

9  
34

1. Which of these Group 2 oxides has the greatest percent by mass oxygen?

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

10  
35

2. The percent by mass of carbon in oxalic acid,  $H_2C_2O_4 \cdot 2H_2O$  is closest to

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

11  
36

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

12  
37

4. Which describes the resulting system when 0.40 moles of  $Na_2CO_{3(s)}$  is added to 0.500 liters of 0.600 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 colorless homogeneous system forms; excess  $CO_3^{2-}$  is found in solution.
- (E) A colorless homogeneous system forms; excess  $Cu^{2+}$  is found in solution.

13 38 8. Which pair of samples contains the same number of atoms of oxygen in each member?

- (A) 0.10 mol  $\text{Al}_2\text{O}_3$  and 0.50 mol  $\text{BaO}$   
 (B) 0.20 mol  $\text{Cl}_2\text{O}$  and 0.10 mol  $\text{HClO}$   
 (C) 0.20 mol  $\text{SnO}$  and 0.20 mol  $\text{SnO}_2$   
 (D) 0.10 mol  $\text{Na}_2\text{O}$  and 0.10 mol  $\text{Na}_2\text{SO}_4$   
 (E) 0.20 mol  $\text{Ca}(\text{OH})_2$  and 0.10 mol  $\text{H}_2\text{C}_2\text{O}_4$

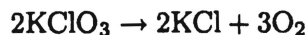
14 39 8.



Which of the following identifies the maximum number of moles of products formed when 0.60 moles of  $\text{ScCl}_3$  is mixed with 0.60 moles  $\text{KOH}$  in water solution?

- |     | mol $\text{Sc}(\text{OH})_3$ | mol $\text{KCl}$ |
|-----|------------------------------|------------------|
| (A) | 0.20                         | 0.20             |
| (B) | 0.20                         | 0.60             |
| (C) | 0.20                         | 1.00             |
| (D) | 0.60                         | 0.20             |
| (E) | 0.60                         | 0.60             |

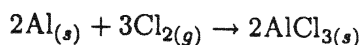
15 40 7.



Which expression gives the mass of  $\text{O}_2$  produced when 15 g  $\text{KClO}_3$  is heated, according to the equation above, in an open vessel until no further weight loss is observed?

- (A)  $15.0 \times \frac{122.5}{1} \times \frac{2}{3} \times \frac{32}{1}$   
 (B)  $15.0 \times \frac{1}{122.5} \times \frac{3}{2} \times \frac{32}{1}$   
 (C)  $15.0 \times \frac{1}{122.5} \times \frac{3}{2} \times \frac{1}{32}$   
 (D)  $15.0 \times \frac{1}{122.5} \times \frac{2}{3} \times \frac{1}{32}$   
 (E)  $15.0 \times \frac{122.5}{1} \times \frac{3}{2} \times \frac{32}{1}$

16 8.  
41



Which expression gives the volume of Cl<sub>2</sub> consumed, measured at STP, when 25 g Al reacts with chlorine according to the above equation?

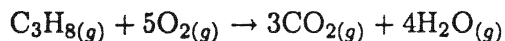
- (A)  $25.0 \times \frac{3}{2} \times \frac{22.4}{2}$
- (B)  $\frac{25.0}{22.4} \times \frac{3}{2} \times \frac{22.4}{2}$
- (C)  $25.0 \times \frac{27}{1} \times \frac{3}{2} \times \frac{22.4}{1}$
- (D)  $25.0 \times \frac{1}{27} \times \frac{3}{2} \times \frac{22.4}{1}$
- (E)  $25.0 \times \frac{1}{27} \times \frac{2}{3} \times \frac{22.4}{1}$

17 8.  
42

Which sample contains the greatest number of nitrogen atoms? (All measurements taken at STP.)

- (A) 0.20 mol N<sub>2</sub>O<sub>4(g)</sub>
- (B) 0.40 mol N<sub>2(g)</sub>
- (C) 40. L NO<sub>2(g)</sub>
- (D) 40. g NH<sub>3(g)</sub>
- (E) 80. g N<sub>2</sub>O<sub>4(g)</sub>

18 10.  
43



Propane gas, C<sub>3</sub>H<sub>8(g)</sub>, burns according to the equation above. A mixture containing 0.030 moles of C<sub>3</sub>H<sub>8(g)</sub> and 0.200 moles of O<sub>2(g)</sub> is placed in a rigid container and its pressure is 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) 0.020 mol C<sub>3</sub>H<sub>8(g)</sub> remains unreacted and the pressure has decreased.
- (B) 0.020 mol C<sub>3</sub>H<sub>8(g)</sub> remains unreacted and the pressure has increased.
- (C) 0.050 mol O<sub>2(g)</sub> remains unreacted and the pressure has decreased.
- (D) 0.050 mol O<sub>2(g)</sub> remains unreacted and the pressure has increased.
- (E) 0.170 mol O<sub>2(g)</sub> remains unreacted and the pressure has decreased.

19 44 11. Samples containing 0.10 mol each of  $[\text{Co}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$  and  $[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$  are treated with excess  $\text{AgNO}_3(\text{aq})$  in separate containers at room temperature. Which describes the quantities of  $\text{AgCl}_{(s)}$  formed?

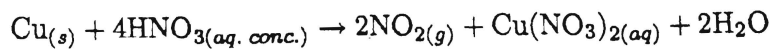
	moles of $\text{AgCl}_{(s)}$ in vessel with	
	$[\text{Co}(\text{H}_2\text{O})_5\text{Cl}]\text{Cl}_2$	$[\text{Co}(\text{H}_2\text{O})_4\text{Cl}_2]\text{Cl}$
(A)	0.10	0.20
(B)	0.20	0.10
(C)	0.30	0.30
(D)	0.60	0.60
(E)	0.80	0.70

20 45 12. A compound is reported to contain 26.6% potassium, 35.3% chromium, and 38.1% oxygen by mass. Which set of values, when substituted for x, y, and z below, gives the best representation of the empirical formula for the unknown compound?

	$\text{K}_x\text{Cr}_y\text{O}_z$		
	x	y	z
(A)	$\frac{39.1}{26.6}$	$\frac{52.0}{35.3}$	$\frac{16.0}{38.1}$
(B)	$\frac{26.6}{16.0}$	$\frac{35.3}{16.0}$	$\frac{38.1}{16.0}$
(C)	$\frac{26.6}{39.1}$	$\frac{35.3}{52.0}$	$\frac{38.1}{16.0}$
(D)	$\frac{39.1}{26.6}$	$\frac{52.0}{26.6}$	$\frac{16.0}{26.6}$
(E)	$\frac{26.6}{52.0}$	$\frac{35.3}{52.0}$	$\frac{38.1}{52.0}$

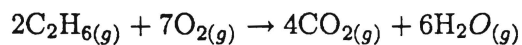
21 46 13. If two compounds have the same empirical formula but different molecular formulas, they must also have different

- (A) molar volumes
- (B) vapor pressures
- (C) molecular masses
- (D) dipole moments
- (E) percent by mass compositions

22 14.  
47

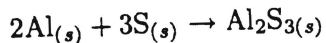
What volume of  $\text{NO}_{2(g)}$  measured at STP can be produced by the reaction of 48 grams of copper with excess concentrated nitric acid according to the equation above?

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

23 16.  
48

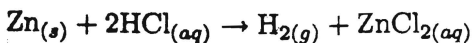
What quantity of reactant remains after ignition of a mixture that contains 0.40 moles of  $\text{C}_2\text{H}_6$  mixed with 1.60 moles of  $\text{O}_2$ ? (Assume maximum reaction according to the equation above.)

- (A) 0.20 mol  $\text{O}_2$
- (B) 0.80 mol  $\text{O}_2$
- (C) 1.20 mol  $\text{O}_2$
- (D) 0.20 mol  $\text{C}_2\text{H}_6$
- (E) 0.30 mol  $\text{C}_2\text{H}_6$

24 28.  
49

What mass of  $\text{Al}_2\text{S}_3$  is produced when 3.00 moles of aluminum reacts with excess sulfur according to the equation above?

- (A) 81.0 g
- (B) 96.0 g
- (C) 123 g
- (D) 150 g
- (E) 225 g

25  
50

21. What volume of  $\text{H}_2$  (measured at STP) is produced when 0.40 moles of zinc reacts with excess 2.5 M HCl according to the equation above?

- (A) 0.40 L
- (B) 0.62 L
- (C) 5.5 L
- (D) 8.9 L
- (E) 22. L

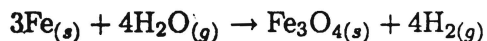
26  
51

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

27  
52

23.



A mixture in a reaction vessel contains 12 moles of iron and 12 moles of steam. A reaction occurs according to the equation above. After the reaction, all gas escapes from the reaction vessel. Which describes the solid phase remaining after heating has occurred?

- (A) 4.0 moles  $\text{Fe}_3\text{O}_4$  and no excess Fe
- (B) 12 moles  $\text{Fe}_3\text{O}_4$  and no excess Fe
- (C) 2.0 moles  $\text{Fe}_3\text{O}_4$  and 6.0 moles excess Fe
- (D) 3.0 moles  $\text{Fe}_3\text{O}_4$  and 3.0 moles excess Fe
- (E) 4.0 moles  $\text{Fe}_3\text{O}_4$  and 8.0 moles excess Fe

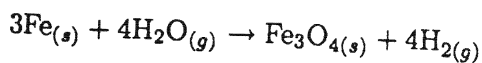
28  
53

24. How many moles of KCl should be added to 0.500 liters of 0.20 M  $\text{CrCl}_3$  solution to increase the chloride concentration to 1.00 M?

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



29  
54 25.



A mixture in a reaction vessel contains 6.0 moles of iron and 12 moles of steam. A reaction occurs according to the equation above. After the reaction, all gas escapes from the reaction vessel. Which describes the contents of the reaction vessel after heating has occurred?

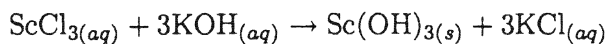
- (A) 2.0 moles Fe<sub>3</sub>O<sub>4</sub> and no excess reactants
- (B) 3.0 moles Fe<sub>3</sub>O<sub>4</sub> and no excess reactants
- (C) 6.0 moles Fe<sub>3</sub>O<sub>4</sub> and no excess reactants
- (D) 2.0 moles Fe<sub>3</sub>O<sub>4</sub> and 2.0 moles excess H<sub>2</sub>O
- (E) 2.0 moles Fe<sub>3</sub>O<sub>4</sub> and 4.0 moles excess H<sub>2</sub>O

36  
55 A.

Which describes the resulting system when 0.40 moles of Na<sub>2</sub>CO<sub>3(s)</sub> is added to 0.500 liters of 0.600 molar CuCl<sub>2</sub> solution?

- (A) A blue precipitate forms; excess CO<sub>3</sub><sup>2-</sup> is found in solution.
- (B) A blue precipitate forms; excess Cu<sup>2+</sup> is found in solution.
- (C) A blue precipitate forms; no excess reactants are found in solution.
- (D) A colorless homogeneous system forms; excess CO<sub>3</sub><sup>2-</sup> is found in solution.
- (E) A colorless homogeneous system forms; excess Cu<sup>2+</sup> is found in solution.

31  
56 B.



Which of the following identifies the maximum number of moles of products formed when 0.60 moles of ScCl<sub>3</sub> is mixed with 0.60 moles KOH in water solution?

- |     | mol Sc(OH) <sub>3</sub> | mol KCl |
|-----|-------------------------|---------|
| (A) | 0.20                    | 0.20    |
| (B) | 0.20                    | 0.60    |
| (C) | 0.20                    | 1.00    |
| (D) | 0.60                    | 0.20    |
| (E) | 0.60                    | 0.60    |

