

Avogadro's Number, $N_A = 6.022 \times 10^{23}$

1. [7 points] Which of the following statements is true?

- (a) Air is an element
- (b) Air is a compound
- (c) Air is a heterogeneous mixture
- (d) Air is a homogeneous mixture
- (e) Air is a pure substance

2. [7 points] What is the empirical formula of the ionic compound that forms between calcium and iodine?

- (a) Ca_3I_2
- (b) Ca_2I
- (c) CaI
- (d) CaI_2
- (e) None of the above

3. [7 points] Which of the following pairs of atoms (ions) have the same number of neutrons?

- (a) $^{65}\text{Zn}^{2+}$ and ^{67}Ge
- (b) $^{87}\text{Sr}^{2+}$ and ^{83}Kr
- (c) $^{16}\text{O}^{2-}$ and ^{19}F
- (d) $^{57}\text{Fe}^{3+}$ and $^{55}\text{Fe}^{2+}$
- (e) None of the above pairs have the same number of neutrons

4. [7 points] What is the empirical formula of potassium sulfite?

- (a) PSO_3
- (b) KSO_4
- (c) K_2SO_4
- (d) K_2SO_3
- (e) K_2S

5. [7 points] How many carbon atoms are present in a single 2.00 ounce shot of pure ethanol ($\text{C}_2\text{H}_5\text{OH}$, density = 0.789 g/cm^3)? [1 ounce = 29.6 mL]

- (a) 6.11×10^{23}
- (b) 1.22×10^{24}
- (c) 1.96×10^{24}
- (d) 1.20×10^{23}
- (e) None of the above

6. [7 points] You are given a solid yellow crystal of unknown composition. After running a series of tests you make the following observations: (a) the crystal is an electrical insulator, (b) if you strike the crystal with a hammer it cracks in several places, (c) if you put the crystal in a beaker of water it dissolves and the resulting solution is found to be a good conductor of electricity. Which of the following substances could have properties consistent with these observations

- (a) Sulfur (S)
- (b) Gold (Au)
- (c) Sodium Chromate (Na_2CrO_4)
- (d) Carbon tetrachloride (CCl_4)
- (e) None of the above choices could have the described properties

7. [7 points] Which of the following statements is **false**?

- (a) Silicon is a metalloid
- (b) Silicon is a molecular compound
- (c) Pure Silicon is an electrical insulator
- (d) Polished Silicon has a shiny appearance, similar to a metal
- (e) Silicon is brittle

8. [7 points] What is the mass of 0.125 moles of iron (III) oxide?

- (a) 12.5 g
- (b) 22.9 g
- (c) 20.0 g
- (d) 7.83×10^{-4} g
- (e) none of the above

9. [7 points] Compositional analysis of the mineral ceria sample reveals that this compound is 81.4% cerium and 18.6% oxygen by mass. What is the empirical formula of this compound?

- (a) CeO
- (b) Ce_4O
- (c) CeO_2
- (d) Ce_2O_3
- (e) Ce_2O

10. [7 points] An unknown compound is subjected to combustion analysis, which reveals that this compound contains 75.69% carbon, 8.80% hydrogen and 15.51% oxygen by mass. A mass spectrometry analysis reveals that the molecular weight is 412 g/mol. What is the molecular formula of this compound?

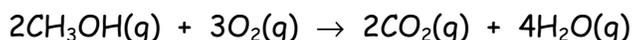
- (a) $C_{26}H_{36}O_4$ (b) $C_{13}H_{18}O_2$ (c) C_9HO_2 (d) $C_{27}H_{24}O_4$
(e) None of the above

11. [7 points] Balance the following reaction and determine the coefficients a , b , c , d and e . What number do you get when you then sum the coefficients together ($a + b + c + d + e$)? (Don't forget the 1's).



- (a) 12 (b) 13 (c) 15 (d) 16 (e) 18

12. [7 points] Given the following balanced chemical equation:



Consider the reaction between 14 methanol (CH_3OH) molecules and 24 oxygen molecules. What molecules will remain after the reaction is complete, assuming the reaction goes to completion.

- (a) 3 molecules O_2 + 14 molecules CO_2 + 28 molecules H_2O
(b) 2 molecules CH_3OH + 16 molecules CO_2 + 32 molecules H_2O
(c) 14 molecules CO_2 + 28 molecules H_2O
(d) 16 molecules CO_2 + 32 molecules H_2O
(e) None of the above

13. [7 points] Sodium hydroxide (FW = 40.0 g/mol) reacts with carbon dioxide (44.0 g/mol) to form sodium carbonate and water. If a 2.40 g sample of sodium hydroxide is reacted with 1.50 g of carbon dioxide, and the reaction goes to completion, what is the theoretical yield of sodium carbonate?

- (a) 1.81 g
(b) 3.61 g
(c) 6.36 g
(d) 3.18 g
(e) None of the above

14. [7 points] In the previous problem what mass of what reactant remains unreacted?

- (a) 0.35 g of carbon dioxide does not react
- (b) 1.32 g of carbon dioxide does not react
- (c) 0.18 g of carbon dioxide does not react
- (d) 1.04 g of sodium hydroxide does not react
- (e) 0.33 g of sodium hydroxide does not react

15. [7 points] What is the concentration of the solution which results when 85.0 mL of 1.84 M KI solution is mixed with 15.0 mL of 0.44 M KI solution?

- (a) 1.63 M
- (b) 0.163 M
- (c) 1.04 M
- (d) 1.54 M
- (e) 0.995 M

16. [7 points] What is the oxidation state (oxidation number) of nitrogen in sodium nitrate?

- (a) +3 (b) -1 (c) +7 (d) +5 (e) -3

17. [7 points] Which of the following substances is a weak electrolyte?

- (a) CCl_4
- (b) KCl
- (c) HCl
- (d) HClO
- (e) None of the above substances are weak electrolytes.

18. [7 points] Which of the following reactions would you expect to produce a gaseous product?

- (a) $\text{MgCO}_3(\text{s}) + \text{NaCl}(\text{aq}) \rightarrow$
- (b) $\text{NaOH}(\text{aq}) + \text{H}_3\text{PO}_4(\text{aq}) \rightarrow$
- (c) $\text{Na}_2\text{CO}_3(\text{aq}) + \text{CuCl}_2(\text{aq}) \rightarrow$
- (d) $\text{AgNO}_3(\text{aq}) + \text{HNO}_3(\text{aq}) \rightarrow$
- (e) None of the above reactions will produce a gaseous product

19. [7 points] What volume of 0.150 M NaOH solution is required to precipitate all of the chromium ions from 54.0 mL of a 0.225 M CrCl₃ solution?

- (a) 81 mL
- (b) 162 mL
- (c) 108 mL
- (d) 54.5 mL
- (e) 243 mL

20. [7 points] In each of the following instances two solutions are mixed together. Which reaction(s) will lead to the formation of a precipitate?

- (a) potassium bromide solution + barium hydroxide solution
- (b) hydrochloric acid solution + barium hydroxide solution
- (c) calcium nitrate solution + sodium hydroxide solution
- (d) ammonium chloride solution + lead (II) nitrate solution
- (e) None of the above reactions will lead to formation of a precipitate

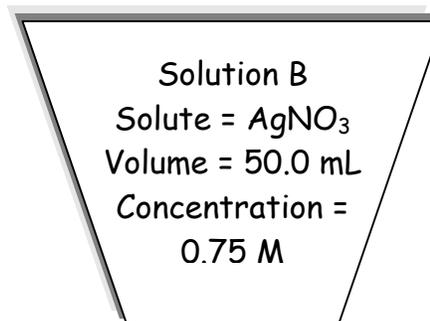
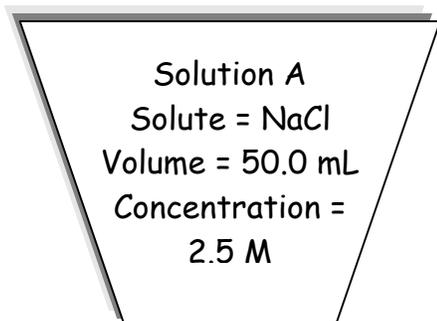
21. [7 points] Which of the following is an example of an oxidation-reduction reaction?

- (a) $\text{HNO}_3(\text{aq}) + \text{KOH}(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{aq}) + \text{KNO}_3(\text{aq})$
- (b) $2\text{Cr}(\text{NO}_3)_3(\text{aq}) + 3(\text{NH}_4)_2\text{CO}_3(\text{aq}) \rightarrow \text{Cr}_2(\text{CO}_3)_3(\text{s}) + 6\text{NH}_4\text{NO}_3(\text{aq})$
- (c) $2\text{HCl}(\text{aq}) + \text{Na}_2\text{S}(\text{s}) \rightarrow 2\text{NaCl}(\text{aq}) + \text{H}_2\text{S}(\text{g})$
- (d) $\text{Zn}(\text{s}) + 2\text{HNO}_3(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{Zn}(\text{NO}_3)_2(\text{aq})$
- (e) Both (c) and (d) are examples of oxidation-reduction reactions

22. [7 points] A strip of zinc metal weighing 1.50 g is placed in 75.0 mL of 2.0 M copper (II) nitrate solution. After the reaction is complete 1.26 g of copper metal is produced. What is the percent yield of copper?

- (a) 13.2%
- (b) 37.1%
- (c) 86.3%
- (d) 146%
- (e) None of the above

23. [7 points] If you mix together the two solutions shown below, what is the concentration of chloride ions in the final mixture?



- (a) 1.63 M
- (b) 0.875 M
- (c) 0.0875 M
- (d) 0.163 M
- (e) None of the above

24. [7 points] If you take an ionic compound, dissolve it into water, and then carry out the following steps:

- I. Add 50 mL of 2.0 M Sr(NO₃)₂ solution. This produces a white precipitate
- II. Next add 50 mL of 2.0 M HCl solution. This causes the precipitate to dissolve and produces a lot of bubbles, but no apparent odor

Which of the following anions (from the original ionic compound) would be consistent with these results.

- (a) OH⁻
- (b) SO₄⁻
- (c) S²⁻
- (d) CO₃²⁻
- (e) PO₄³⁻

25. [7 points] Which of the following is the correct net ionic equation for the reaction between nitrous acid and magnesium hydroxide?

- (a) H⁺ (aq) + OH⁻ (aq) → H₂O (l)
- (b) 2H⁺ (aq) + Mg(OH)₂ (s) → 2H₂O (l) + Mg²⁺
- (c) 2HNO₂ (aq) + Mg(OH)₂ (s) → 2H₂O (l) + Mg(NO₂)₂ (aq)
- (d) 2HNO₂ (aq) + 2OH⁻ (s) → 2H₂O (l) + NO₃⁻ (aq)
- (e) None of the above