

Multiple Choice: (4 points each. Put answers in left margin as capital letters.)

- How many significant figures are in the answer to the following problem: $\frac{2.511 - 2.311}{2736}$?
A) 1 B) 2 C) 3 D) 4 E) 5
- What is the concentration of a sodium chloride (NaCl) solution after 40 mL of water is added to 60 mL of a solution that is initially 2.00 M?
A) 0.67 M B) 0.80 M C) 1.20 M D) 1.33 M E) 2.00 M
- Which of the following ionic compounds has the lowest water solubility?
A) CaSO₄ B) CoCO₃ C) KCl D) (NH₄)₂S E) Ni(NO₃)₂
- Which of the following is a precipitation reaction?
A) Cu(OH)_{2(aq)} + 2 HNO_{3(aq)} → Cu(NO₃)_{2(aq)} + 2 H₂O_(l)
B) H₂SO_{4(aq)} + 2 NH_{3(aq)} → (NH₄)₂SO_{4(aq)}
C) FeCl_{3(s)} + 3 AgNO_{3(g)} → 3 AgCl_(s) + 3 Fe(NO)_{3(aq)}
D) 2 SrS_(s) + 2 HCl_(aq) → SrCl_{2(aq)} + H₂S_(g)
E) None is a precipitation reaction.
- What is the oxidation number of the phosphorus atom in Mg₃(PO₄)₂?
A) -1 B) +1 C) +3 D) +5 E) +7
- Which of the following is a formation reaction?
A) 2 Al_(s) + 3 O_(g) → Al₂O_{3(s)} D) 2 Al_(g) + ³/₂ O_{2(g)} → Al₂O_{3(s)}
B) 2 Al_(s) + ³/₂ O_{2(g)} → Al₂O_{3(s)} E) None of the above.
C) 4 Al_(g) + 3 O_{2(g)} → 2 Al₂O_{3(s)}
- Which of the following processes is endothermic?
A) Water freezing. C) The reaction of sodium and water E) A block resting on a table
B) Coal burning. D) A light bulb emitting light
- What is ΔH for the net reaction below?
H_{2(g)} + F_{2(g)} → 2 HF_(g) ΔH = -537 kJ
C_(s) + 2 F_{2(g)} → CF_{4(g)} ΔH = -680 kJ
2 C_(s) + 2 H_{2(g)} → C₂H_{4(g)} ΔH = 52.3 kJ
C₂H_{4(g)} + 6 F_{2(g)} → 2 CF_{4(g)} + 4 HF_(g) ΔH = ?
A) -2,486 kJ B) -1,702 kJ C) -1,165 kJ D) 234 kJ E) 1,165 kJ

9. Which of the following is a statement of the first law of thermodynamics?
- A) Energy can be freely exchanged between the system and the surroundings only in an open container.
 - B) The enthalpy of a reaction is independent of the number of steps taken.
 - C) Energy can be neither created nor destroyed.
 - D) It is possible to measure the exact energy of a substance only at absolute zero (0 K).
 - E) The heat of reaction of any spontaneous process must be negative.

Discussion Questions: (Show your work to receive credit.)

1. A solution of CaCl_2 in water forms a mixture that is 22.0% calcium chloride by mass. If the total mass of the solution is 166.1 g, what masses of CaCl_2 and water were used? What is the CaCl_2 molar concentration? Assume the solution density is 1.00 g/mL. (10 points)

$$\text{mass}_{\text{CaCl}_2} = (166.1 \text{ g}_{\text{soln}}) \left(\frac{0.220 \text{ g}_{\text{CaCl}_2}}{1 \text{ g}_{\text{soln}}} \right) = 36.5 \text{ g}_{\text{CaCl}_2}$$

$$\text{mass}_{\text{H}_2\text{O}} = 166.1 \text{ g}_{\text{soln}} - 36.5 \text{ g}_{\text{CaCl}_2} = 129.6 \text{ g}_{\text{H}_2\text{O}}$$

$$[\text{CaCl}_2] = (36.5 \text{ g}_{\text{CaCl}_2}) \left(\frac{1 \text{ mol}_{\text{CaCl}_2}}{110.98 \text{ g}_{\text{CaCl}_2}} \right) \left(\frac{1}{166.1 \text{ g}} \right) \left(\frac{1.00 \text{ g}_{\text{soln}}}{\text{mL}_{\text{soln}}} \right) \left(\frac{1000 \text{ mL}_{\text{soln}}}{\text{L}_{\text{soln}}} \right) = 1.98 \text{ M}$$

2. Propane burns according to the reaction: $\text{C}_3\text{H}_8 (\text{g}) + 5 \text{O}_2 (\text{g}) \rightarrow 3 \text{CO}_2 (\text{g}) + 4 \text{H}_2\text{O} (\ell)$

If 10.0 g of propane is reacted with 5.00 g of oxygen, which of the reactants is limiting?

What is the maximum mass of carbon dioxide that can be produced? What is the percent yield if 50.0 g of CO_2 is made? (15 points)

$$\text{mol}_{\text{C}_3\text{H}_8} = (10.00 \text{ g}_{\text{C}_3\text{H}_8}) \left(\frac{1 \text{ mol}_{\text{C}_3\text{H}_8}}{44.10 \text{ g}_{\text{C}_3\text{H}_8}} \right) = 0.2268 \text{ mol}_{\text{C}_3\text{H}_8}$$

$$\text{mol}_{\text{O}_2} = (5.00 \text{ g}_{\text{O}_2}) \left(\frac{1 \text{ mol}_{\text{O}_2}}{32.00 \text{ g}_{\text{O}_2}} \right) = 0.15625 \text{ mol}_{\text{O}_2}$$

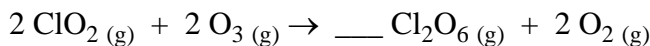
$$\text{mol}_{\text{O}_2}(\text{needed}) = (0.2268 \text{ mol}_{\text{C}_3\text{H}_8}) \left(\frac{5 \text{ mol}_{\text{O}_2}}{1 \text{ mol}_{\text{C}_3\text{H}_8}} \right) = 1.134 \text{ mol}_{\text{O}_2}$$

but we have only 0.15625 mol_{O₂} which is not enough to completely react all of the C₃H₈ so O₂ is the limiting reagent.

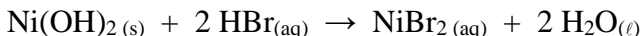
$$\text{mol}_{\text{CO}_2} = (5.00 \text{ g}_{\text{O}_2}) \left(\frac{1 \text{ mol}_{\text{O}_2}}{32.00 \text{ g}_{\text{O}_2}} \right) \left(\frac{3 \text{ mol}_{\text{CO}_2}}{5 \text{ mol}_{\text{O}_2}} \right) \left(\frac{44.01 \text{ g}_{\text{CO}_2}}{1 \text{ mol}_{\text{CO}_2}} \right) = 12.4 \text{ g}_{\text{CO}_2} \text{ will be produced.}$$

$$\% \text{ yield} = \frac{10.0 \text{ g}_{\text{CO}_2}}{12.4 \text{ g}_{\text{CO}_2}} \times 100\% = 80.6\%$$

3. Complete the following: (10 points)



Solid nickel(II) hydroxide reacts with aqueous hydrobromic acid to produce aqueous nickel(II) bromide and water.



4. What are standard conditions in thermochemistry? (4 points) 25 °C and 1 atm pressure
5. A researcher studying the nutritional value of a new candy places a 6.40 g sample of the candy inside a bomb calorimeter and combusts it in excess oxygen. The observed temperature increase is 2.11 °C. If the heat capacity of the calorimeter is 42.90 kJ•K⁻¹, how many kilojoules are there per gram of candy? (5 points)

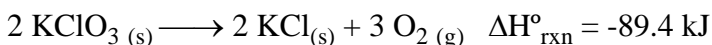
$$\Delta T = 2.11 \text{ °C} = 2.11 \text{ K.}$$

$$\text{Energy}_{\text{sample}} = \left(\frac{42.90 \text{ kJ}}{\text{K}} \right) (2.11 \text{ K}) = 90.5 \text{ kJ}$$

$$\text{Energy}_{\text{g candy}} = \frac{90.5 \text{ kJ}}{6.40 \text{ g}} = 14.1 \text{ kJ/g}$$

6. Is the following process exothermic, endothermic, or neither? Explain. (10 points)
 - a) $\text{CO}_2 (\text{s}) \rightarrow \text{CO}_2 (\text{g})$ Endothermic, because energy must be put in to disrupt the attractions that hold the solid together.
 - b) $2 \text{I} (\text{g}) \rightarrow \text{I}_2 (\text{g})$ Exothermic, because energy is released from the attractions involved in creating the I-I bond

7. From the following data: (10 points)



- a) Is the reaction endothermic or exothermic?
- b) How much energy would be absorbed or released if 10.75 g of potassium chloride formed?
- c) If an unknown quantity of potassium chlorate is burned with a heat change of -325 kJ, what mass of potassium chlorate burned?

a) exothermic

$$\text{b) } \Delta H = (10.75 \text{ g}_{\text{KCl}}) \left(\frac{1 \text{ mol}_{\text{KCl}}}{74.55 \text{ g}_{\text{KCl}}} \right) \left(\frac{-89.4 \text{ kJ}}{2 \text{ mol}_{\text{KCl}}} \right) = -6.44 \text{ kJ}$$

$$\text{c) } \text{mass}_{\text{KClO}_3} = (325 \text{ kJ}) \left(\frac{2 \text{ mol}_{\text{KClO}_3}}{-89.4 \text{ kJ}} \right) \left(\frac{122.5 \text{ g}_{\text{KClO}_3}}{1 \text{ mol}_{\text{KClO}_3}} \right) = 891 \text{ g}_{\text{KClO}_3}$$