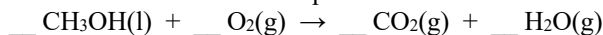
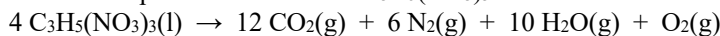


Part I: Multiple Choice Questions (100 Points) *Use a scantron sheet for Part I.* There is *only* one best answer for each question.

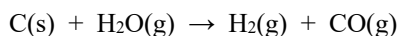
1. When methanol undergoes complete combustion, the products are carbon dioxide and water according to the equation below. What are the respective coefficients when the equation is balanced with the smallest whole numbers?



- a. 1, 1, 1, 1
b. 1, 2, 1, 2
c. 2, 2, 2, 4
d. 2, 3, 2, 4
e. 2, 4, 6, 4
2. Write a balanced chemical equation for the combustion of pentane, C_5H_{12} .
- a. $\text{C}_5\text{H}_{12}(\text{g}) + 8 \text{O}_2(\text{g}) \rightarrow 5 \text{CO}_2(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$
b. $\text{C}_5\text{H}_{12}(\text{g}) \rightarrow 5 \text{C}(\text{s}) + 6 \text{H}_2(\text{g})$
c. $\text{C}_5\text{H}_{12}(\text{g}) + 9 \text{O}_2(\text{g}) \rightarrow 4 \text{CO}_2(\text{g}) + 5 \text{H}_2\text{O}(\text{g})$
d. $\text{C}_5\text{H}_{12}(\text{g}) + 11 \text{O}_2(\text{g}) \rightarrow \text{C}_5\text{O}_{10}(\text{g}) + 6 \text{H}_2\text{O}(\text{g})$
e. $\text{C}_5\text{H}_{12}(\text{g}) + 11 \text{O}_2(\text{g}) \rightarrow 5 \text{CO}_2(\text{g}) + 12 \text{H}_2\text{O}(\text{g})$
3. Aluminum reacts with oxygen to produce aluminum oxide. If 5.0 moles of Al react with excess O_2 , how many moles of Al_2O_3 can be formed? The reaction: $4 \text{Al}(\text{s}) + 3 \text{O}_2(\text{g}) \rightarrow 2 \text{Al}_2\text{O}_3(\text{s})$
- a. 1.0 mol
b. 2.0 mol
c. 2.5 mol
d. 5.0 mol
e. 10.0 mol
4. Nitroglycerine decomposes violently according to the **balanced** chemical equation below. How many total moles of gases are produced from the decomposition of 1.00 mol $\text{C}_3\text{H}_5(\text{NO}_3)_3$?

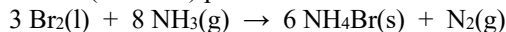


- a. 4.00 mol
b. 6.50 mol
c. 7.25 mol
d. 16.5 mol
e. 29.0 mol
5. The reaction of water and coal at a high temperature produces a mixture of hydrogen and carbon monoxide gases. This mixture is known as synthesis gas (or syngas). What mass of hydrogen gas can be formed from the reaction of 51.3 g of carbon with excess water?



- a. 4.31 g
b. 8.61 g
c. 17.2 g
d. 1.20×10^2 g
e. 306 g

6. If 0.250 moles of bromine and 0.600 moles of ammonia react according to the equation below, what is the maximum amount of ammonium bromide (in moles) produced?



- a. 0.250 mol
b. 0.450 mol
c. 0.500 mol
d. 0.600 mol
e. 0.800 mol
7. The reaction of 10.0 g $\text{H}_2(\text{g})$ with 10.0 g $\text{O}_2(\text{g})$ yields 8.43 g $\text{H}_2\text{O}(\text{g})$. What is the percent yield of this reaction?
- a. 9.43%
b. 27.3%
c. 42.2%
d. 66.8%
e. 74.6%
8. A mass of 2.052 g of a metal carbonate, MCO_3 , is heated to give the metal oxide and 0.4576 g CO_2 . What is the identity (*hint*: molar mass!) of the metal? The balanced equation: $\text{MCO}_3(\text{s}) \rightarrow \text{MO}(\text{s}) + \text{CO}_2(\text{g})$
- a. Cu
b. Mg
c. Ca
d. Ba
e. Co
9. Which one of the following compounds is a nonelectrolyte when dissolved in water?
- a. $\text{CH}_3\text{CH}_2\text{OH}$
b. ZnBr_2
c. LiCl
d. $\text{Ca}(\text{NO}_3)_2$
e. KOH
10. Which of the following compounds will be soluble in water: LiOH , $\text{Mg}(\text{OH})_2$, $\text{Cu}(\text{OH})_2$, and $\text{Fe}(\text{OH})_3$?
- a. LiOH only
b. LiOH and $\text{Mg}(\text{OH})_2$
c. $\text{Cu}(\text{OH})_2$ and $\text{Fe}(\text{OH})_3$
d. $\text{Mg}(\text{OH})_2$ and $\text{Cu}(\text{OH})_2$
e. LiOH , $\text{Mg}(\text{OH})_2$, and $\text{Fe}(\text{OH})_3$
11. A white solid is either $\text{Pb}(\text{NO}_3)_2$ or $\text{Zn}(\text{NO}_3)_2$. If an aqueous solution is prepared, which reagent will allow you to distinguish between the two compounds?
- a. KBr
b. HNO_3
c. $\text{CH}_3\text{CO}_2\text{H}$
d. NH_4ClO_4
e. LiNO_3

12. What is the net ionic equation for the reaction of aqueous lead(II) nitrate with aqueous sodium bromide?
- $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NaBr}(\text{aq}) \rightarrow \text{PbBr}_2(\text{aq}) + 2 \text{NaNO}_3(\text{s})$
 - $\text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{NaNO}_3(\text{s})$
 - $\text{Pb}^{2+}(\text{aq}) + 2 \text{Br}^-(\text{aq}) \rightarrow \text{PbBr}_2(\text{s})$
 - $\text{Pb}^{2+}(\text{aq}) + 2 \text{Na}^+(\text{aq}) \rightarrow \text{PbNa}_2(\text{s})$
 - $\text{Pb}(\text{NO}_3)_2(\text{aq}) + 2 \text{NaBr}(\text{aq}) \rightarrow \text{PbBr}_2(\text{s}) + 2 \text{NaNO}_3(\text{aq})$
13. What are the spectator ions in the reaction between aqueous perchloric acid and aqueous potassium hydroxide?
- H^+ , ClO_4^- , K^+ , and OH^-
 - H^+ and OH^-
 - K^+ and ClO_4^-
 - H^+ and ClO_4^-
 - K^+ and OH^-
14. Which species in the reaction undergoes reduction? $\text{Sn}(\text{s}) + 2 \text{H}^+(\text{aq}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$
- Sn
 - H^+
 - Sn^{2+}
 - H_2
 - No compound is reduced.
15. What is the oxidation number of iodine in IO_3^- ?
- 1
 - 0
 - +3
 - +5
 - +7
16. Which of the following are oxidation-reduction reactions?
- $\text{Zn}(\text{s}) + \text{CuSO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + \text{Cu}(\text{s})$
 - $\text{Pb}(\text{ClO}_4)_2(\text{aq}) + 2 \text{KI}(\text{aq}) \rightarrow \text{PbI}_2(\text{s}) + 2 \text{KClO}_4(\text{aq})$
 - $\text{CaCO}_3(\text{s}) \rightarrow \text{CO}_2(\text{g}) + \text{CaO}(\text{s})$
- 1 only
 - 2 only
 - 1 and 2
 - 1 and 3
 - 2 and 3
17. What is the mass of solute in 225 mL of $5.91 \times 10^{-2} \text{ M KIO}_3$?
- 0.0133 g
 - 0.0562 g
 - 0.263 g
 - 1.51 g
 - 2.85 g

18. What is the pH of 0.27 M HNO_3 ?

- a. 0.57
- b. 1.31
- c. 1.86
- d. 2.70
- e. 13.43

19. Which one of the following statements is INCORRECT?

- a. In an exothermic process heat is transferred from the system to the surroundings.
- b. The greater the heat capacity of an object, the more thermal energy it can store.
- c. The SI unit of specific heat capacity is joules per gram per kelvin.
- d. The specific heat capacity has a positive value for liquids and a negative value for gases.
- e. When heat is transferred from the system to the surroundings, q is negative.

20. If 136 J is required to change the temperature of 8.75 g of nickel by 35.0 K, what is the specific heat capacity of mercury?

- a. 0.0294 J/g·K
- b. 0.311 J/g·K
- c. 0.417 J/g·K
- d. 0.444 J/g·K
- e. 2.25 J/g·K

21. If the same amount of heat is added to 5.00 g samples of each of the metals below, which metal will experience the smallest temperature change?

<u>Metal</u>	<u>Specific Heat Capacity (J/g·K)</u>
Al	0.897
Au	0.129
Cu	0.385
Fe	0.449
K	0.753

- a. Al
- b. Au
- c. Cu
- d. Fe
- e. K

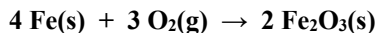
22. If 50.0 g H_2O at 13.6 °C is combined with 85.0 g H_2O at 93.7 °C, what is the final temperature of the mixture?

- a. 26.1 °C
- b. 40.0 °C
- c. 56.1 °C
- d. 64.0 °C
- e. 80.1 °C

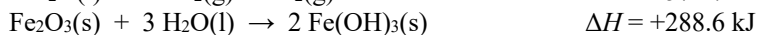
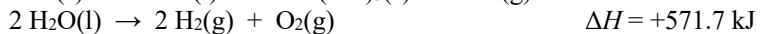
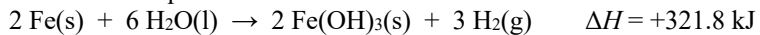
23. The heat of vaporization of benzene, C_6H_6 , is 30.8 kJ/mol at its boiling point of 80.1 °C. How much heat is required to vaporize 128 g benzene at its boiling point?
- 4.04 kJ
 - 18.8 kJ
 - 19.3 kJ
 - 50.5 kJ
 - 4.04×10^3 kJ
24. The balanced thermochemical equation for the combustion of hexane is shown below. What is the enthalpy change for the combustion of 2.50 g of C_6H_{14} ?
- $$C_6H_{14}(g) + \frac{19}{2} O_2(g) \rightarrow 6 CO_2(g) + 7 H_2O(g) \quad \Delta H^\circ = -4163 \text{ kJ}$$
- 121 kJ
 - -1.66×10^3 kJ
 - -1.04×10^4 kJ
 - -1.43×10^5 kJ
 - -3.59×10^5 kJ
25. Which of the following chemical equations corresponds to the standard molar enthalpy of formation of N_2O ?
- $NO(g) + \frac{1}{2} N_2(g) \rightarrow N_2O(g)$
 - $N_2(g) + \frac{1}{2} O_2(g) \rightarrow N_2O(g)$
 - $2 N(g) + O(g) \rightarrow N_2O(g)$
 - $N_2(g) + O(g) \rightarrow N_2O(g)$
 - $2 N_2(g) + O_2(g) \rightarrow 2 N_2O(g)$

Part II: Short Answer / Calculation. *Show all work!*

1. Determine the heat of reaction for the oxidation of iron,



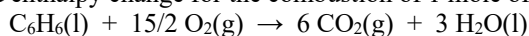
given the thermochemical equations below.



Part II: Short Answer / Calculation (*continued*) *Show all work!*

2. Benzoic acid contains C, H, and O atoms. When 1.500 g benzoic acid is burned in oxygen, 3.784 g CO₂ and 0.6639 g H₂O are produced. The molar mass of the compound is found to be 122.12 g/mol. Use this information to find the **empirical formula and molecular formula** of benzoic acid.

3. The standard enthalpy change for the combustion of 1 mole of benzene is -3267.4 kJ.



Calculate ΔH_f° for benzene based on the following standard molar enthalpies of formation.

<u>molecule</u>	<u>ΔH_f° (kJ/mol)</u>
CO ₂ (g)	-393.5
H ₂ O(l)	-285.8

Extra Credit Question: Use the above problem to calculate the energy (in kJ) released upon burning 15.0 g of benzene.