

INTRODUCTORY CHEMISTRY, CHEM 111
TEST 4, SPRING 2006

Name _____

Multiple Choice: Circle the best answer for each question. There is only one correct answer to each question.

- In Part C of the thermochemistry experiment you reacted NaOH(aq) with HC₂H₃O₂(aq) by the following reaction. $\text{NaOH(aq)} + \text{HC}_2\text{H}_3\text{O}_2\text{(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{NaC}_2\text{H}_3\text{O}_2\text{(aq)}$
A 150 mL sample of 1.0M NaOH(aq) is reacted with 200 mL of 1.0M HC₂H₃O₂(aq) resulting in a solution with a mass of 357 g. The temperature of the solution increases by 5.89 K. The specific heat of the solution is 4.00 J/gK. How much heat is transferred to the water?
a) 8.41×10^3 J b) 5.89 J c) 2.36×10^3 J d) 3.53×10^3 J
e) none of these
- For the above problem determine the change in enthalpy for the reaction. NaOH is the limiting reagent in the reaction
a) -16 kJ/mol_{rxn} b) -24 kJ/mol_{rxn} c) -56 kJ/mol_{rxn} d) -59 kJ/mol_{rxn}
e) none of these
- The change in enthalpy for the following reaction is -2511.14 kJ/mol_{rxn}. How much heat will be given off by the reaction when 0.120 moles of C₂H₂ reacts with an excess of oxygen?
 $2 \text{C}_2\text{H}_2\text{(g)} + 5 \text{O}_2\text{(g)} \rightarrow 4 \text{CO}_2\text{(g)} + 2 \text{H}_2\text{O(g)}$
a) 125 kJ b) 151 kJ c) 445 kJ d) 8.30 kJ
e) 301 kJ
- Use enthalpy of atom combination data to determine the change in enthalpy associated with the following reaction. $\text{PH}_3\text{(g)} + 2 \text{O}_2\text{(g)} \rightarrow \text{H}_3\text{PO}_4\text{(s)}$
 $\Delta H^\circ_{\text{ac}} \text{PH}_3 = -962.2 \text{ kJ/mol}_{\text{rxn}}$, $\Delta H^\circ_{\text{ac}} \text{O}_2 = -498.3 \text{ kJ/mol}_{\text{rxn}}$, $\Delta H^\circ_{\text{ac}} \text{H}_3\text{PO}_4 = -3243.3 \text{ kJ/mol}_{\text{rxn}}$
a) +1958.8 kJ/mol_{rxn} b) -1284.5 kJ/mol_{rxn} c) -1460.5 kJ/mol_{rxn}
d) +1460.5 kJ/mol_{rxn} e) -1782.8 kJ/mol_{rxn}
- The enthalpy of atom combination of carbon dioxide, CO₂(g), is -1608 kJ/mol_{rxn}. Estimate the bond strength (the energy required to break a mole) of carbon-oxygen double bonds.
a) 804 kJ/mol b) 1608 kJ/mol c) 3216 kJ/mol d) 36.5 kJ/mol
e) none of these
- The following reaction is exothermic. Which of the following statements is true about the reactions?
 $\text{CH}_4\text{(g)} + 2 \text{O}_2\text{(g)} \rightarrow \text{CO}_2\text{(g)} + 2 \text{H}_2\text{O(g)}$
a) The bond strengths of the reactants are greater than the bond strengths of the products.
b) The bond strengths of the products are greater than the bond strengths of the reactants.
c) The bond strengths of the reactants and products must be equal in all chemical reactions.
d) none of these are true
- Use the following data
 $\text{H}_2\text{(g)} + \frac{1}{2} \text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O(l)}$ $\Delta H^\circ = -285.83 \text{ kJ/mol}_{\text{rxn}}$
 $\text{H}_2\text{(g)} + \text{O}_2\text{(g)} \rightarrow \text{H}_2\text{O}_2\text{(aq)}$ $\Delta H^\circ = -191.17 \text{ kJ/mol}_{\text{rxn}}$
to calculate ΔH° for the decomposition of hydrogen peroxide.
 $2 \text{H}_2\text{O}_2\text{(aq)} \rightarrow 2 \text{H}_2\text{O(l)} + \text{O}_2\text{(g)}$
a) 477kJ/mol_{rxn} b) -94.66 kJ/mol_{rxn} c) -380.49 kJ/mol_{rxn} d) -189.32 kJ/mol_{rxn}
e) 96.51 kJ/mol_{rxn}

8. List all the types of intermolecular forces that would exist between CO₂ molecules.
- only dispersion forces
 - dispersion, dipole/induced dipole and dipole/dipole forces
 - only dipole/dipole forces
 - dispersion, dipole/induced dipole, dipole/dipole, and hydrogen bonding forces
 - dispersion and dipole/induced dipole forces

Use the following table to answer questions 9-12

Boiling Points of Three Classes of Organic Compounds

Alkane	MW (g/mol)	BP (°C)	Aldehyde	MW (g/mol)	BP (°C)	Carboxylic Acid	MW (g/mol)	BP (°C)
Butane CH ₃ (CH ₂) ₂ CH ₃	58.1	-0.5	Butanal CH ₃ (CH ₂) ₂ CHO	72.1	75.7	Butanoic acid CH ₃ (CH ₂) ₂ COOH	88.1	164
Pentane CH ₃ (CH ₂) ₃ CH ₃	72.2	36.1	Pentanal CH ₃ (CH ₂) ₃ CHO	86.1	103	Pentanoic acid CH ₃ (CH ₂) ₃ COOH	102.1	186
Hexane CH ₃ (CH ₂) ₄ CH ₃	86.2	69.0	Hexanal CH ₃ (CH ₂) ₄ CHO	100.2	128	Hexanoic acid CH ₃ (CH ₂) ₄ COOH	116.2	205
Heptane CH ₃ (CH ₂) ₅ CH ₃	100.2	98.4	Heptanal CH ₃ (CH ₂) ₅ CHO	114.2	153	Heptanoic acid CH ₃ (CH ₂) ₅ COOH	130.2	223
Octane CH ₃ (CH ₂) ₆ CH ₃	114.2	126	Octanal CH ₃ (CH ₂) ₆ CHO	128.2	171	Octanoic acid CH ₃ (CH ₂) ₆ COOH	144.2	239

9. Which of the following compounds has the strongest total intermolecular forces?
- octanal
 - butanoic acid
 - hexane
 - pentanal
 - octane
10. What intermolecular force is responsible for the difference in boiling point between pentanoic acid and octanoic acid?
- dispersion
 - dipole/induced dipole
 - dipole/dipole
 - hydrogen bonding
 - covalent bonds
11. What intermolecular force is responsible for the difference in boiling point between hexane and pentanal?
- dispersion
 - ionic bonds
 - dipole/dipole
 - hydrogen bonding
 - covalent bonds
12. Predict the boiling point of nonanoic acid, CH₃(CH₂)₇COOH.
- 152°C
 - 135°C
 - 68°C
 - 125°C
 - 255°C
13. Given the reaction $\text{CS}_2(\text{l}) + 3 \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g}) + 2 \text{SO}_2(\text{g}) \quad \Delta H = -1076.82 \text{ kJ/mol}_{\text{rxn}}$
Which of the following statements is true?
- The reaction is exothermic and the products are in a higher energy state than the reactants.
 - The reaction is exothermic and the products are in a lower energy state than the reactants.
 - The reaction is endothermic and the products are in a higher energy state than the reactants.
 - The reaction is endothermic and the products are in a lower energy state than the reactants.
14. Which of the following compounds would you expect to have the highest boiling point?
- PH₃
 - PH₂Cl
 - PHCl₂
 - PCl₃
 - the boiling points would be equivalent

Key:

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|------|-------|-------|-------|
| 1. a | 6. b | 11. c | 16. b |
| 2. c | 7. d | 12. e | 17. c |
| 3. b | 8. a | 13. b | 18. c |
| 4. b | 9. a | 14. d | 19. d |
| 5. a | 10. a | 15. d | 20. a |

1. Enthalpies of combination describe the formation of compounds from their gaseous atoms. This is a bond making process.
2. Increases. Increasing temperature increases the average kinetic energy of the molecules in the liquid state. Therefore, a greater number of these molecules have the minimum required energy to overcome their intermolecular forces and to escape into the gaseous state.
3. $-802.34 \text{ kJ/mol}_{\text{rxn}}$