GENERAL CHEMISTRY I  
CHEM 1311  
Sample Exam on Gas Laws and Thermochemistry

Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Boyle’s law can be used to solve problems involving a process that is

a) isobaric b) isochoric c) isothermal

2. A process in which the pressure does not change is said to be

a) isobaric b) isochoric c) isothermal

3. An isochoric process is one in which the \_\_\_\_\_\_\_\_\_\_ does not change.

a) pressure b) temperature c) volume

4. If the pressure does not change during a process, you can use \_\_\_\_\_\_\_\_\_\_ law to solve problems involving the process.

a) Boyle’s b) Charles’ c) Gay-Lussac’s

5. Problems involving an isochoric process are solved using \_\_\_\_\_\_\_\_\_\_ law.

a) Boyle’s b) Charles’ c) Gay-Lussac’s

6. Boyle’s law can be used to solve problems in which the \_\_\_\_\_\_\_\_\_\_ remains constant.

a) pressure b) temperature c) volume

7. A gas was confined in a cylinder fitted with a movable piston. At 24.1 oC, the gas occupied a volume of 4.815 L under a pressure of 2.173 atm. The gas was isothermally compressed to a volume of 3.019 L. What pressure was exerted by the compressed gas?

a) 3.466 atm b) 4.981 atm c) 5.873 atm d) 6.736 atm e) 7.502 atm

8. A gas was confined in a cylinder fitted with a movable piston. At 23.6 oC, the gas occupied a volume of 7.942 L under a pressure of 2.061 atm. The gas was isobarically heated, causing it to expand to a volume of 9.540 L. What was the temperature of the heated gas?

a) 28.3 oC b) 39.9 oC c) 52.4 oC d) 68.7 oC e) 83.3 oC

9. A gas was confined in a rigid steel tank having a volume of 7.832 L. At 19.8 oC, the gas exerted a pressure of 6.733 atm. The gas was isochorically heated to a temperature of 95.6 oC. What pressure was exerted by the heated gas?

a) 7.451 atm b) 8.475 atm c) 10.01 atm d) 11.99 atm e) 14.85 atm

10. A gas was confined in a cylinder fitted with a movable piston. At 22.1 oC, the gas occupied a volume of 5.143 L under a pressure of 1.995 atm. The gas was simultaneously heated and compressed, so that its pressure was 4.034 atm and its temperature was 75.8 oC. What volume was occupied by the hot compressed gas?

a) 0.577 L b) 1.356 L c) 2.171 L d) 3.006 L e) 4.427 L

11. What pressure is exerted by 8.908 g of O2 gas in a 5.722 L tank at 31.6 oC? Note that the gas constant R has the value 0.08205 L atm / K mol. Atomic weight: O = 16.00 g/mol.

a) 1.216 atm b) 3.284 atm c) 5.176 atm d) 6.953 atm e) 8.482 atm

12. A steel tank contains 4.772 g of N2 under a pressure of 2.087 atm at 23.6 oC. What is the volume of the tank? Note that the gas constant R has the value 0.08205 L atm / K mol.   
Atomic weight: N = 14.01 g/mol

a) 1.987 L b) 3.163 L c) 4.728 L d) 7.385 L e) 9.508 L

13. A steel tank having a volume of 9.715 L contains CO2 gas under a pressure of 7.263 atm at 37.9 oC. What mass of CO2 is in the tank? Note that the gas constant R has the value 0.08205 L atm / K mol. Atomic weights: C = 12.01 g/mol O = 16.00 g/mol

a) 23.08 g b) 56.11 g c) 85.91 g d) 121.7 g e) 177.8 g

14. What is the density of N2 gas at 28.4 oC and 7.937 atm? Note that the gas constant R has the value 0.08205 L atm / K mol. Atomic weight: N = 14.01 g/mol

a) 2.433 g/L b) 3.941 g/L c) 5.338 g/L d) 6.790 g/L e) 8.988 g/L

15. An unknown gas has a density of 1.686 g/L when the pressure is 2.503 atm and the temperature is 35.0 oC. What is the molecular weight of this gas? Note that the gas constant R has the value 0.08205 L atm / K mol.

a) 2.015 g/mol b) 4.003 g/mol c) 17.03 g/mol d) 28.01 g/mol e) 44.01 g/mol

16. What is the identity of the unknown gas in the previous problem? The following atomic weights will be helpful in working out your answer to this problem: H = 1.008 g/mol C = 12.01 g/mol  
N = 14.01 g/mol O = 16.00 g/mol He = 4.003 g/mol

a) CO b) CO2 c) H2 d) He e) NH3

17. A steel tank having a volume of 6.823 L contains 5.227 g of CH4 and 9.840 g of NO at 38.5 oC. What is the total pressure exerted by this gas mixture? Note that the gas constant R has the value 0.08205 L atm / K mol. Atomic weights: H = 1.008 g/mol C = 12.01 g/mol  
N = 14.01 g/mol O = 16.00 g/mol

a) 1.338 atm b) 2.450 atm c) 4.179 atm d) 6.512 atm e) 9.284 atm

18. A steel tank having a volume of 7.392 L contains a mixture of N2 and CO2 gases at 32.6 oC. The total pressure exerted by the gas mixture is 3.952 atm. If the mixture contains 8.758 g of N2, what mass of CO2 is present? Note that the gas constant R has the value 0.08205 L atm / K mol.  
Atomic weights: C = 12/01 g/mol N = 14.01 g/mol O = 16.00 g/mol

a) 5.421 g/mol b) 13.84 g/mol c) 24.56 g/mol d) 37.49 g/mol e) 55.91 g/mol

19. If it takes 48.17 minutes for CO2 to effuse through a small hole in its container, show long would it take for NH3 to effuse under the same conditions of temperature and pressure (comparisons being for the same number of moles of effused gas)? Atomic weights: H = 1.008 g/mol C = 12.01 g/mol  
N = 14.01 g/mol O = 16.00 g/mol

a) 4.317 min b) 18.64 min c) 29.97 min d) 124.5 min e) 321.7 min

20. If it takes 37.16 minutes for N2 to effuse through a small hole in a container, and an unknown gas requires 56.19 minutes under the same conditions of temperature and pressure (comparisons being for the same number of moles of effused gas), what is the molecular weight of the unknown gas?  
Atomic weight: N = 14.01 g/mol

a) 16.04 g/mol b) 32.00 g/mol c) 44.01 g/mol d) 64.07 g/mol e) 80.06 g/mol

21. What is the identity of the unknown gas in the previous problem? The following atomic weights will be helpful in working out your answer to this problem.  
Atomic weights: H = 1.008 g/mol C = 12.01 g/mol O = 16.00 g/mol S = 321.07 g/mol

a) CH4 b) CO2 c) O2 d) SO2 e) SO3

22. An endothermic reaction \_\_\_\_\_\_\_\_\_\_ heat.

a) absorbs b) releases

23. A closed system

a) exchanges matter, but not energy, with the surroundings

b) exchanges energy, but not matter, with the surroundings

c) exchanges both matter and energy with the surroundings

d) exchanges neither matter nor energy with the surroundings

24. If an exothermic reaction takes place in an isolated system, the temperature of the system will

a) decrease b) increase c) remain constant

25. When taking place in a system that is not isolated, an endothermic reaction causes \_\_\_\_\_\_\_\_\_\_ of the immediate surroundings.

a) warming b) cooling

26. Consider a system made up of 5 sub-systems A, B, C, D and E that are in thermal contact with each other and isolated from the surroundings. The sub-systems were all initially at different temperatures, but after a redistribution of heat among these sub-systems, thermal equilibrium was established and all sub-systems had the same temperature. The following is a description of the heat flow with respect to sub-systems A, B, C, and D:

Sub-system A lost 5 kJ of heat.  
Sub-system B gained 9 kJ of heat.  
Sub-system C lost 2 kJ of heat.  
Sub-system D gained 6 kJ of heat.

What happened to sub-system E?

a) sub-system E lost 4 kJ of heat b) sub-system E lost 6 kJ of heat

c) sub-system E gained 6 kJ of heat d) sub-system E lost 8 kJ of heat

e) sub-system E gained 8 kJ of heat

27. Consider a system made up of 5-sub-systems A, B, C, D, and E that are in thermal contact with each other and isolated from the surroundings. The sub-systems were all initially at different temperatures, but after a redistribution of heat among these sub-systems, thermal equilibrium was established and all sub-systems had the same temperature. The following is a description of the heat flow with respect to sub-systems A, B, C and D:

Sub-system A lost 7 kJ of heat.

Sub-system B gained 2 kJ of heat.

Sub-system C lost 5 kJ of heat.

Sub-system D gained 6 kJ of heat.

What happened to sub-system E?

a) sub-system E lost 4 kJ of heat b) sub-system E lost 6 kJ of heat

c) sub-system E gained 4 kJ of heat d) sub-system E gained 6 kJ of heat

e) sub-system E gained 8 kJ of heat

28. How much heat is required to raise the temperature of 841.2 g of aluminum from 21.4 oC to 89.9 oC? Note that the specific heat capacity of aluminum is 0.903 J/goC.

a) 21.8 kJ b) 36.1 kJ c) 52.0 kJ d) 71.3 kJ e) 94.8 kJ

29. A 421.8 g sample of water, initially at 20.2 oC, absorbs 56.19 kJ of heat. What is the temperature of the water after absorbing this heat? Note that the specific heat capacity of water is 4.18 J/goC

a) 31.9 oC b) 40.0 oC c) 52.1 oC d) 65.9 oC e) 77.6 oC

30. A 389.5 g sample of water, initially at 86.3 oC, loses 47.32 kJ of heat. What is the temperature of the water after losing this heat? Note that the specific heat capacity of water is 4.18 J/goC.

a) 16.3 oC b) 29.1 oC c) 57.2 oC d) 69.4 oC e) 80.2 oC

31. A 5.00 g sample of a metal was heated to 100.0 oC and dropped into 10.00 g of water at 25.0 oC. The hot metal lost heat to the cold water, and the final equilibrium temperature was 28.8 oC. What was the specific heat capacity of the metal? Assume no loss of heat to the walls of the calorimeter, and no exchange of heat with the surroundings.

a) 0.14 J/goC b) 0.24 J/goC c) 0.39 J/goC d) 0.45 J/goC e) 0.54 J/goC

32. A 75.22 g sample of water at 83.7 oC was mixed with a 59.12 g sample of water at 20.6 oC. What was the final equilibrium temperature of the combined masses of water? Assume all the heat lost by the hot water is gained by the cold water. That is, no exchange of heat with the calorimeter walls or the surroundings. The specific heat capacity of water is 4.18 J/goC.

a) 31.4 oC b) 42.6 oC c) 55.9 oC d) 63.4 oC e) 75.2 oC

33. A metal alloy having a mass of 5.216 g was heated to 94.8 oC and dropped into a calorimeter containing 15.83 g of water at 22.4 oC. What will be the final equilibrium temperature of this system? The specific heat capacity of the metal alloy is known to be 0.752 J/goC, and that of water to be 4.18 J/goC. Assume that all of the heat lost by the hot metal is gained by the cold water. That is, ignore any loss of heat to the walls of the calorimeter, and any exchange of heat between the calorimeter and the surroundings.

a) 23.3 oC b) 25.1 oC c) 26.5 oC d) 27.9 oC e) 29.9 oC

34. The thermochemical equation for the reaction of nitrogen and hydrogen to form ammonia (NH3) is

N2(g) + 3H2(g) 🡪 2NH3(g) H = -92.22 kJ

What is H for the reaction of 7.183 g of N2 in the above equation?  
Atomic weights: H = 1.008 g/mol N = 14.01 g/mol

a) -12.35 kJ b) -23.64 kJ c) -47.29 kJ d) -68.19 kJ e) -85.41 kJ

35. The thermochemical equation for the combustion of methane (CH4) is

CH4(g) + 2O2(g) 🡪 CO2(g) + 2H2O(g) H = -802 kJ

What is H for the reaction rewritten in the form

½CH4(g) + O2(g) 🡪 ½CO2(g) + H2O(g) ΔH = ?

a) -1604 kJ b) -802 kJ c) -401 kJ d) 401 kJ e) 802 kJ

36. The thermochemical equation for the reaction of oxygen and nitrogen monoxide to form nitrogen dioxide is

2NO(g) + O2(g) 🡪 2NO2(g) ΔH = -114 kJ

What is ΔH for the reaction rewritten in the form

NO2(g) 🡪 NO(g) + ½O2(g) ΔH = ?

a) -114 kJ b) -57 kJ c) 57 kJ d) 114 kJ e) 228 kJ

37. The following are the thermochemical equations for the formation of lead(II) oxide and lead(IV) chloride:

2Pb(s) + O2(g) 🡪 2PbO(s) ΔH = -434.6 kJ

Pb(s) + O2(g) 🡪 PbO2(s) ΔH = -277.0 kJ

Using the above thermochemical equations, and applying Hess’ law, determine ΔH for the following reaction:

2PbO(s) + O2(g) 🡪 2PbO2(g) ΔH = ?

a) -988.6 kJ b) -711.6 kJ c) -592.2 kJ d) -157.6 kJ e) -119.4 kJ

38. The following are the thermochemical equations for the formation of hydrogen sulfide (H2S), water, and sulfur dioxide (SO2), all in the gaseous state:

H2(g) + S(s) 🡪 H2S(g) ΔH = -20.6 kJ

2H2(g) + O2(g) 🡪 2H2O(g) ΔH = -483.6 kJ

S(s) + O2(g) 🡪 SO2(g) ΔH = -296.9 kJ

Using the above thermochemical equations, and applying Hess’ law, determine ΔH for the following reaction:

2H2S(g) + 3O2(g) 🡪 2H2O(g) + 2SO2(g) ΔH = ?

a) -1036.2 kJ b) -801.1 kJ c) -621.8 kJ d) 69.0 kJ e) 151.4 kJ

39. Use standard enthalpies of formation (ΔHf values) to calculate the enthalpy change (ΔH) for the reaction

Fe2O3(s) + 3CO(g) 🡪 2Fe(s) + 3CO2(g)

Note the following standard enthalpies of formation:

Substance ΔHf

Fe2O3(s) -824.2 kJ/mol

CO(g) -110.5 kJ/mol

CO2(g) -393.5 kJ/mol

Fe(s) 0 kJ/mol

a) -24.8 kJ b) -283.0 kJ c) -849.0 kJ d) -1328.2 kJ e) -2336.2 kJ

40. The thermochemical equation for the combustion of butane is

2C4H10(g) + 13O2(g) 🡪 8CO2(g) + 10H2O(g) ΔH = -5314.6 kJ

Using the value of ΔH given for this reaction, and the standard enthalpies of formation (ΔHf values) for O2(g), CO2(g), and H2O(g), calculate the standard enthalpy of formation (ΔHf) for C4H10(g). Note the following standard enthalpies of formation:

Substance ΔHf

O2(g) 0 kJ/mol

CO2(g) -393.5 kJ/mol

H2O(g) -241.8 kJ/mol

a) -317.7 kJ/mol b) -251.4 kJ/mol c) -125.7 kJ/mol d) 125.7 kJ/mol e) 251.4 kJ/mol