Chemistry 121 | Fall 2007 | Oregon State University
Exam 2 | November 15, 2007 | Dr. Richard Nafshun

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. **Leave the class section number and the test form number blank.**

This exam consists of 25 multiple-choice questions. Each question has four points associated with it. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form and note card in the appropriate stacks. You may keep the exam packet, so please show your work and mark the answers you selected on it.

Abbreviated Solubility Rules:
Rule 1: All nitrates, group 1A metal salts and ammonium salts are soluble.
Rule 2: All carbonates, hydroxides, phosphates and sulfides are insoluble.
Rule 3: Rule 1 always takes precedent.

$R = 0.0821 \frac{L \bullet atm}{mol \bullet K}$	$R = 8.314 \frac{kg \bullet m^2}{s^2 \bullet mol \bullet K}$	$\mu_{rms} = \sqrt{\frac{3RT}{Molar\ Mass}}$
$PV = nRT$	760 Torr = 1 atm = 760 mm Hg	$K = 273.15 + °C$
$1\ mole = 6.02 \times 10^{23}$	$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$	milli (m) = 1/1000 kilo (k) = 1000
$M_1V_1 = M_2V_2$	$M_{acid}V_{acid} = M_{base}V_{base}$	

Hydroxide OH^-	Cyanide CN^-	Nitrate NO_3^-
Acetate CH_3COO^-	Carbonate CO_3^{2-}	Phosphate PO_4^{3-}
Hydronium H_3O^+	Ammonium NH_4^+	Sulfate SO_4^{2-}

Substance	FM (g/mol)	MP (°C)	Heat (f) (J/g)	BP (°C)	Heat (v) (J/g)	Specific Heat (J/g°C)* Solid	Liquid	Gas
acetone	58.1	-95.1	96.7	56.1	520	2.26	2.20	1.46
benzene	78.1	5.41	126	80.1	394	1.20	1.90	1.17
ethanol	46.1	-112	100	78.3	852	0.96	2.10	1.71
n-octane	114	-57.0	182	126	339	1.30	2.40	1.30
water	18.0	0.00	334	100	2260	2.09	4.18	1.38

* Values are estimated based on averages over the temperature range

Substance	ΔH_f (kJ/mol)	Substance	ΔH_f (kJ/mol)
$C_{(s)}$	0	$NH_{3(g)}$	-46.2
$CO_{(g)}$	-110.5	$NO_{(g)}$	+90.4
$CO_{2(g)}$	-393.5	$NO_{2(g)}$	+33.8
$CH_{4(g)}$	-74.8	$N_2O_{4(g)}$	+9.7
$CH_3OH_{(g)}$	-201.2	$O_{2(g)}$	0
$H_{2(g)}$	0	$S_{(s)}$	0
$H_2O_{(g)}$	-241.8	$SO_{2(g)}$	-296.9
$H_2S_{(g)}$	-20.6	$SO_{3(g)}$	-395.2
$N_{2(g)}$	0		

hide thermo. quant.

$2625.8\,g\ Xe\left(\frac{1\ mol}{131.29\,g}\right) = 20.00\ mol$

1. A student  obtains a 653.65 liter weather balloon that contains 2625.8 grams of xenon gas at 293 K. The pressure inside the weather balloon is:

(A) 1.36 atm
(B) 96.6 atm
(C) 0.0103 atm
(D) 22.4 atm
(E) 0.736 atm

$PV = nRT$

$P = \frac{nRT}{V} = \frac{(20.00\ mol)\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(293\ K)}{653.65\ L} =$

$P = 0.736\ atm$

2. A student  places 3.23 g of a gas into a 10.0-L container at 298 K and measures the pressure to be 0.247 atm. This gas is:

(A) O_2 (g)
(B) N_2 (g)
(C) Cl_2 (g)
(D) H_2 (g)
(E) He (g)

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(0.247\ atm)(10.0\ L)}{\left(0.0821\ \frac{L \cdot atm}{mol \cdot K}\right)(298\ K)} = 0.101\ mol$

$\text{Molar Mass} = \frac{g}{mol} = \frac{3.23\ g}{0.101\ mol} = 32.0\ g/mol$

O_2 is $32.0\ g/mol$

3. A student obtains a 2.50 liter balloon 312 K and 1.21 atm. She cools the balloon to 280 K. The volume of the balloon at 280 K is:

(A) 2.24 L
(B) 0.446 L
(C) 2.71 L
(D) 1.85 L
(E) 0.541 L

$\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\qquad \frac{2.50\ L}{312\ K} = \frac{V_2}{280\ K}$

$V_2 = 2.24\ L$

4. The root-mean-square speed of H_2 (g) at 0.983 atm and 313.1 K is:

(A) 3874 m/s
(B) 3.874×10^6 m/s
(C) 1968 m/s
(D) 6.224×10^6 m/s
(E) 1040 m/s

$$u_{rms} = \sqrt{\frac{3RT}{\text{Molar Mass}}}$$

$$u_{rms} = \sqrt{\frac{3\left(8.314 \frac{kg \cdot m^2}{s^2 \cdot mol \cdot K}\right)(313.1\ K)}{0.00202 \frac{kg}{mol}}}$$

needs to be in $\frac{kg}{mol}$

$$u_{rms} = 1968 \frac{m}{s}$$

5. Consider the following five gases: H_2 (g) O_2 (g) He (g) Cl_2 (g) Ar (g)

Of these, the gas with the **highest** velocity at room temperature is:

(A) H_2 (g) $2\ g/mol$ ↓ Lightest
(B) O_2 (g)
(C) He (g)
(D) Cl_2 (g)
(E) Ar (g)

6. A student combusts 168.32 grams of ethene gas, C_2H_4. How many liters of CO_2 (g) are produced at a pressure of 0.993 atm and a temperature of 295 K?

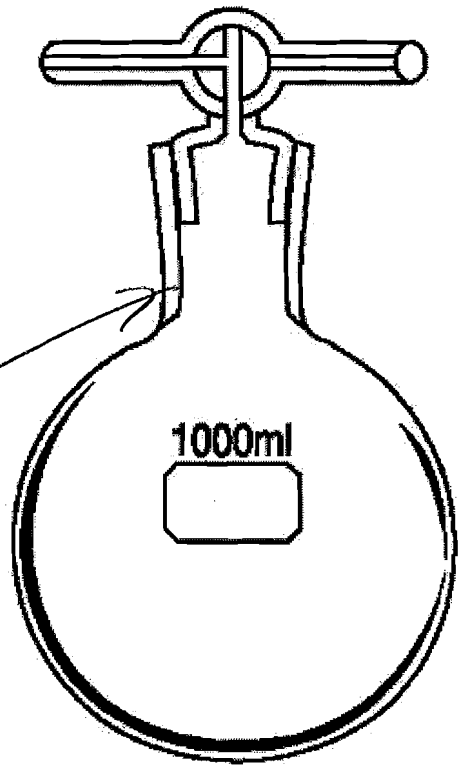
$$C_2H_4\ (g) + 3\ O_2\ (g) \rightarrow 2\ CO_2\ (g) + 2\ H_2O\ (g)$$

168.22 g ↓ 6.000 mol → 12.000 mol ↑ L

$$V = \frac{nRT}{P} = \frac{(12.000\ mol)\left(0.0821 \frac{L \cdot atm}{mol \cdot K}\right)(295\ K)}{0.993\ atm} = 293\ L$$

(A) 3.42×10^{-3} L of CO_2 are formed
(B) 146.3 L of CO_2 are formed
(C) 6.00 L of CO_2 are formed
(D) 293 L of CO_2 are formed
(E) 14.63 L of CO_2 are formed

7. A student obtains a 1.000 liter glass bottle of fixed volume at 24.1 °C and 0.989 atm. The student closes the bottle containing air [78% N_2 (g); 21% O_2 (g); 1% other gases]. The student places the bottle over a Bunsen burner so the bottle and the air heat up to 30.5 °C. Which of the following is true?



Here is a sample bottle

Fixed volume is the key

(A) The gases inside the bottle are traveling faster at the higher temperature than at the lower temperature; the pressure inside the bottle is higher at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is higher at the higher temperature than at the lower temperature.

(B) The gases inside the bottle are traveling the same velocity at the higher temperature than at the lower temperature; the pressure inside the bottle is higher at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is higher at the higher temperature than at the lower temperature.

(C) The gases inside the bottle are traveling the same velocity at the higher temperature than at the lower temperature; the pressure inside the bottle is the same at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is the same at the higher temperature than at the lower temperature.

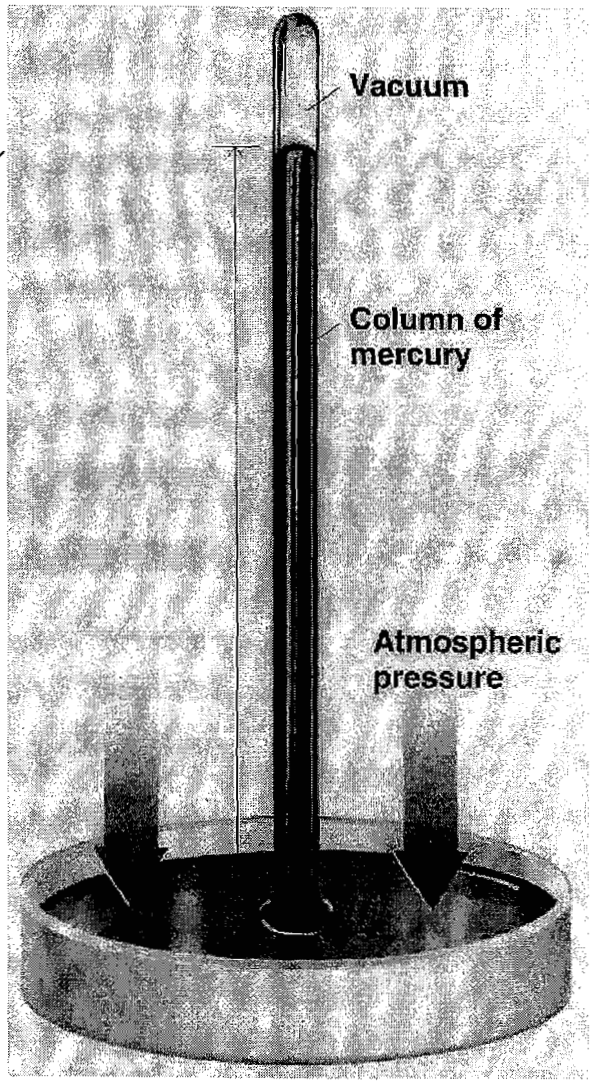
(D) The gases inside the bottle are traveling faster at the higher temperature than at the lower temperature; the pressure inside the bottle is higher at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is the same at the higher temperature than at the lower temperature.

(E) The gases inside the bottle are traveling the same velocity at the higher temperature than at the lower temperature; the pressure inside the bottle is lower at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is the same at the higher temperature than at the lower temperature.

8. A student measures the pressure inside their home to be 1.00 atm. How high would the column of mercury be in a barometer?

(A) 100 mm
(B) 1000 mm
(C) 273 mm
(D) 760 mm
(E) 200.59 mm

760 mm Hg = 1 atm



9. What is the density (in g/L) of He (g) at 298 K and 1.00 atm?

(A) 4.0026 g/L
(B) 0.164 g/L
(C) 6.11 g/L
(D) 298 g/L
(E) 24.5 g/L

1 mole He 4.00260 g

$$V = \frac{nRT}{P} = \frac{(1\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(298\ \text{K})}{1.00\ \text{atm}} = 24.5\ \text{L}$$

$$d = \frac{g}{L} = \frac{4.00260\ \text{g}}{24.5\ \text{L}} = 0.164\ \text{g/L}$$

10. A sample of Ar (g) is observed to effuse through a porous barrier in 1.72 minutes. Under the same conditions, the same number of moles of an unknown gas requires 0.544 minutes to effuse through the same barrier. Which of the following is the unknown gas?

(A) O_2 (g)
(B) N_2 (g)
(C) Cl_2 (g)
(D) H_2 (g)
(E) He (g)

$$\frac{\text{time}_1}{\text{time}_2} = \frac{\sqrt{\text{Molar Mass}_1}}{\sqrt{\text{Molar Mass}_2}}$$

$$\frac{1.72\ \text{min}}{0.544\ \text{min}} = \frac{\sqrt{39.948\ \text{g/mol}}}{\sqrt{\text{Molar Mass}_2}}$$

$\text{Molar Mass}_2 = 4.00\ \text{g/mol}$

He is $4.00\ \text{g/mol}$

11. A system takes in 450 kJ of heat and does 230 kJ of work. The change in the internal energy of the system is:

(A) + 680 kJ
(B) - 680 kJ
(C) + 220 kJ
(D) - 220 kJ
(E) + 103,500 kJ

$\Delta E = q + w = (+450\ \text{kJ}) + (-230\ \text{kJ}) =$

$\Delta E = +220\ \text{kJ}$

12. Which of the following processes is exothermic?

(A) $H_2O\ (s) \rightarrow H_2O\ (l)$
(B) $C_3H_8\ (l) + 5\ O_2\ (g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (g)$ Combustion
(C) $H_2O\ (l) \rightarrow H_2O\ (g)$
(D) $NH_4NO_3\ (s) \rightarrow NH_4NO_3\ (aq)$
(E) $CO_2\ (s) \rightarrow CO_2\ (g)$

13. How much heat is required to raise the temperature of 480 grams of water from 50.0°C to 60.0°C?

(A) 20.1 kJ
(B) 4800 kJ
(C) 4.80 kJ
(D) 1440 kJ
(E) 48.0 kJ

$q = mc\Delta T = (480\,g)(4.18\,\frac{J}{g\cdot°C})(60°C - 50°C) =$

$q = 20,064\ J = 20.1\ kJ$

14. How much heat is required to vaporize 500 grams of water?

(A) 0.500 kJ
(B) 1130 kJ
(C) 2090 kJ
(D) 161 kJ
(E) 221 kJ

$q = m H_{vap} = (500\,g)(2260\ J/g) = 1,130,000\ J$

$= 1,130\ kJ$

15. A process gives off 110 kJ of heat. This process is:

(A) endothermic
(B) exothermic — heat is given off

16. The heat of formation ($\Delta H°_f$) of NH_4Cl (s) is –315.4 kJ/mol. The chemical equation associated with this reaction is:

(A) NH_4 (s) + Cl (g) → NH_4Cl (s)
(B) ½ N_2 (g) + 2 H_2 (g) + ½ Cl_2 (g) → NH_4Cl (s)
(C) NH_4^+ (aq) + Cl^- (aq) → NH_4Cl (s)
(D) NH_4^+ (s) + Cl^- (s) → NH_4Cl (s)
(E) ½ N_2 (g) + 4 HCl (aq) → NH_4Cl (s) + 3/2 Cl_2 (g)

one mole of product

elements in their natural state

17. What is $\Delta H^\circ_{reaction}$ for the following reaction (thermodynamic data is available at the front of the exam)?

$$2\ SO_2\ (g) \quad + \quad O_2\ (g) \quad \rightarrow \quad 2\ SO_3\ (g)$$

$-296.9\ kJ/mol \qquad \varnothing \qquad -395.2\ kJ/mol$

$\Delta H^\circ_{rxtn} = \Delta H^\circ_{final} - \Delta H^\circ_{initial} = [2\ mol\ SO_3\ (-395.2\ kJ/mol)] -$

$[2\ mol\ SO_2\ (-296.9\ kJ/mol) + 1\ mol\ O_2(0)] =$

$= -196.6\ kJ$

(A) - 98.3 kJ
(B) - 790.4 kJ
(C) - 196.6 kJ
(D) - 1384.2 kJ
(E) + 1384.2 kJ

18. Consider:

$$C_7H_{16}\ (l) + 11\ O_2\ (g) \rightarrow 7\ CO_2\ (g) + 8\ H_2O\ (l) \qquad \Delta H^\circ_{reaction} = -4130\ kJ$$

How much energy is released when 2.000 moles of C_7H_{16}, is combusted?

(A) 4130 kJ
(B) 2065 kJ
(C) 17263 kJ
(D) 8260 kJ
(E) 0 kJ

$-4130\ kJ \times 2 = -8260\ kJ$

↑ exothermic - this energy is released

19. Which of the following statements is correct (data for water and benzene are provided on the front page)?

(A) It takes more heat to raise the temperature of 50 grams of liquid water five degrees than it does to raise the temperature of 50 grams of liquid benzene five degrees.

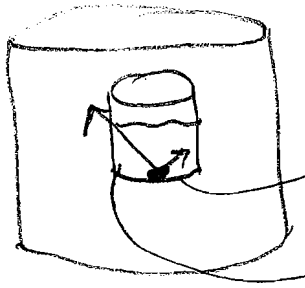
(B) It takes less heat to raise the temperature of 50 grams of liquid water five degrees than it does to raise the temperature of 50 grams of liquid benzene five degrees.

$C_{H_2O} > C_{benzene}$

$4.18\ J/g\cdot{}^{\circ}C$ $1.90\ J/g\cdot{}^{\circ}C$

20. A student dissolves 20.0 grams of a solid into 250.0 grams of water in a calorimeter. The solution takes in 212 J of heat and the calorimeter takes in 103 J of heat. How much heat was released from the reaction when the solid was dissolved?

(A) 83.6 J
(B) 20900 J
(C) 109 J
(D) 456 J
(E) 315 J



heat given off = 212 J

heat given off = 103 J

212 J + 103 J = 315 J

21. Determine $\Delta H°$ for: $4\ H_2O\ (l) + 2\ NH_3\ (g) \rightarrow 2\ NO_2(g) + 7\ H_2\ (g)$ using the following two equations:

(1) $N_2\ (g) + 3\ H_2\ (g) \rightarrow 2\ NH_3\ (g)$ $\quad \Delta H_1° = -184$ kJ Flip

(2) $4\ NO_2\ (g) + 8\ H_2\ (g) \rightarrow 2\ N_2\ (g) + 8\ H_2O\ (l)$ $\quad \Delta H_2° = -196$ kJ Flip $\times \frac{1}{2}$

New (1) $2\ NH_3(g) \rightarrow N_2(g) + 3\ H_2(g)$ $\quad \Delta H_1' = +184$ kJ

New (2) $N_2(g) + 4\ H_2O(\ell) \rightarrow 2\ NO_2(g) + 4\ H_2(g)$ $\quad \Delta H_2' = \frac{+196\ kJ}{2}$

$2\ NH_3(g) + 4\ H_2O(\ell) \rightarrow 2\ NO_2(g) + 7\ H_2(g)$ $\quad \Delta H = +282$ kJ

(A) - 380 kJ
(B) + 380 kJ
(C) + 12 kJ
(D) - 576 kJ
(E) + 282 kJ

22. A student dissolves one mole of $Al(NO_3)_3$ into a beaker of water. How many nitrate ions are present in the solution?

(A) There are one mole nitrate ions in the beaker.
(B) There are two moles nitrate ions in the beaker.
(C) There are three moles nitrate ions in the beaker.
(D) There are six moles nitrate ions in the beaker.
(E) There are eight moles nitrate ions in the beaker.

23. A student mixes an aqueous solution of $Hg(NO_3)_2$ (aq) with an aqueous solution of Na_2S (aq). Which of the following statements is **FALSE**?

(A) NO_3^- is a spectator ion. ✓
(B) Na^+ is a spectator ion. ✓
(C) Hg^{2+} ions will combine with S^{2-} ions will form the insoluble HgS (s). ✓
(D) Na^+ ions will combine with NO_3^- ions will form the insoluble $NaNO_3$ (s).

Na^+ & NO_3^- are soluble

24. Consider the mixture of two aqueous solutions: one of lithium carbonate and one of barium nitrate. The net ionic equation for the process that occurs is:

(A) $Ba^{2+}(aq) + 2\ NO_3^-(aq) \rightarrow Ba(NO_3)_2(s)$
(B) $Li^+(aq) + NO_3^-(aq) \rightarrow LiNO_3(s)$
(C) $Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$
(D) $2\ Li^+(aq) + 2\ NO_3^-(aq) \rightarrow 2\ LiNO_3(s)$
(E) $Li_2CO_3(aq) + Ba(NO_3)_2(aq) \rightarrow BaCO_3(s) + 2\ LiNO_3(aq)$

25. Which one of the following statements is **TRUE**?

(A) The CH 121 Final Exam is scheduled for 4:00-5:50pm on Tuesday, December 4, 2007
(B) The CH 121 Final Exam is scheduled for 4:00-5:50pm on Tuesday, December 4, 2007
(C) The CH 121 Final Exam is scheduled for 4:00-5:50pm on Tuesday, December 4, 2007
(D) The CH 121 Final Exam is scheduled for 4:00-5:50pm on Tuesday, December 4, 2007
(E) The CH 121 Final Exam is scheduled for 4:00-5:50pm on Tuesday, December 4, 2007

[Any response will receive full credit; even no response]