Chemistry 121 | Fall 2008 | Oregon State University
Exam 2 | November 20, 2008 | 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 = 6.02×10^{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		

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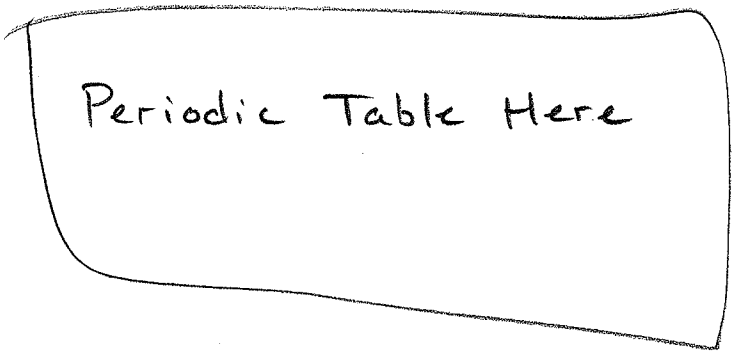


1. A student  places 1.854 g of a gas into a 1.12-L container at 273 K and measures the pressure to be 0.977 atm. This gas is:

(A) H_2
(B) F_2
(C) Cl_2
(D) N_2
(E) O_2

$$\text{Molar Mass} = \frac{g}{mol} = \frac{1.854\ g}{0.0488\ mol} = 38\ g/mol \quad F_2 \text{ on list}$$

$$n = \frac{PV}{RT} = \frac{(0.977\ atm)(1.12\ L)}{(0.0821\ \frac{L \cdot atm}{mol \cdot K})(273\ K)} = 0.0488\ mol$$

2. What is the density (in g/L) of O_2 (g) at 298 K and 1.00 atm?

(A) 4.0026 g/L
(B) 0.164 g/L
(C) 1.31 g/L
(D) 298 g/L
(E) 24.5 g/L

$1\ mol = 32\ g$

$$V = \frac{nRT}{P} = \frac{(1\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(298\ K)}{(1\ atm)} = 24.47\ L$$

$$d = \frac{g}{L} = \frac{32\ g}{24.47\ L} = 1.31\ \frac{g}{L}$$

3. A student  obtains a 4.08 liter flask that contains 10.09 grams of Ne (g) at 305 K. The pressure inside the flask is:

(A) 3.07 atm
(B) 61.9 atm
(C) 12,556 atm
(D) 22.4 atm
(E) 1.03 atm

$$10.09\ g\left(\frac{1\ mol}{20.179\ g}\right) = 0.500\ mol$$

$$P = \frac{nRT}{V} = \frac{(0.500\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(305\ K)}{(4.08\ L)} = 3.07\ atm$$

4. A student obtains a 4.00 liter balloon at 298 K and 0.982 atm. The student cools the balloon to 200 K. The volume of the balloon at 200 K is:

(A) 2.68 L
(B) 0.373 L
(C) 786 L
(D) 1.27×10^{-3} L
(E) 1170 L

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\quad \frac{4.00\ L}{298\ K} = \frac{V_2}{200\ K}$ $\quad V_2 = 2.68\ L$

5. The root-mean-square speed of N_2 (g) at 760 mm Hg and 297 K is:

(A) 3874 m/s
(B) 3.874×10^6 m/s
(C) 514 m/s
(D) 264 m/s
(E) 1040 m/s

$u_{rms} = \sqrt{\frac{3RT}{\text{Molar Mass}}} = \sqrt{\frac{(3)(8.314\ \frac{kg \cdot m^2}{s^2 \cdot mol \cdot K})(297\ K)}{28.01 \times 10^{-3}\ \frac{kg}{mol}}}$

$= 514\ \frac{m}{s}$

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

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

(A) H_2 (g) 2 g/mol ← Most massive
(B) O_2 (g) 32
(C) He (g) 4
(D) Cl_2 (g) 70
(E) Ar (g) 40

7. A student inflates a balloon to 3.58 liters at 28.6 °C and 1.02 atm. The student seals the balloon which contains expired air [74% N_2 (g); 16% O_2 (g); 4% CO_2 (g); 5% H_2O (g); 1% trace gases]. The student cools the balloon to 2.09 °C. Which of the following is true?

(A) The gases inside the balloon are traveling slower at the lower temperature than at the higher temperature; the volume of the balloon is smaller at the lower temperature than at the higher temperature; the number of moles of gas present inside the balloon at the lower temperature is the same as at the higher temperature; the pressure inside the balloon at the lower temperature is the same as at the higher temperature.

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

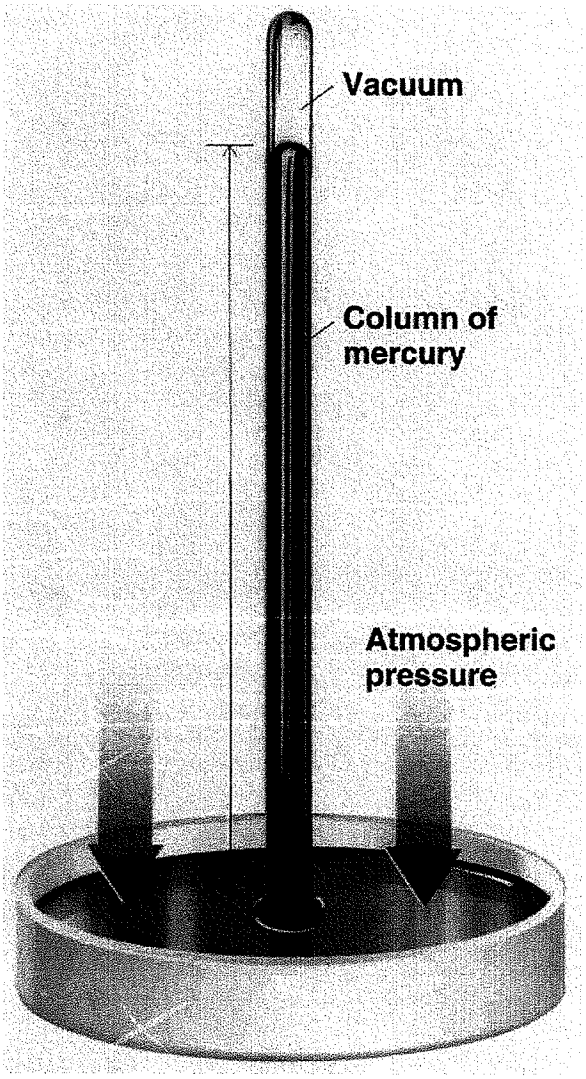
(C) The gases inside the balloon are traveling slower at the lower temperature than at the higher temperature; the volume of the balloon is the same at the lower temperature as at the higher temperature; the number of moles of gas present inside the balloon at the lower temperature is the same as at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

(D) The gases inside the balloon are traveling slower at the lower temperature than at the higher temperature; the volume of the balloon is smaller at the lower temperature than at the higher temperature; the number of moles of gas present inside the balloon at the lower temperature is the same as at the higher temperature; the pressure inside the balloon at the lower temperature is smaller than at the higher temperature.

(E) The gases inside the balloon are traveling slower at the lower temperature than at the higher temperature; the volume of the balloon is smaller at the lower temperature than at the higher temperature; the number of moles of gas present inside the balloon at the lower temperature is less than at the higher temperature; the pressure inside the balloon at the lower temperature is the same as at the higher temperature

8. A student measures the pressure inside their home to be 0.981 atm. How high would the column of mercury be in a barometer?

(A) 0.0013 mm
(B) 1000 mm
(C) 746 mm
(D) 760 mm
(E) 273 mm



$0.981\ atm \left(\frac{760\ mmHg}{1\ atm}\right) = 746\ mm\ Hg$

9. A sample of Cl_2 (g) is observed to effuse through a porous barrier in 0.855 minutes. Under the same conditions, the same number of moles of an unknown gas requires 1.16 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) Xe (g)

$$\frac{time_1}{time_2} = \frac{\sqrt{Molar\ Mass_1}}{\sqrt{Molar\ Mass_2}} \qquad \frac{0.855\ min}{1.16\ min} = \frac{\sqrt{70.91\ g/mol}}{\sqrt{Molar\ Mass_2}}$$

$Molar\ mass_2 = 130.5\ g/mol$

10. A student combusts 12.000 moles of pentane, C_5H_{12}. How many liters of CO_2 (g) are produced at a pressure of 1.080 atm and a temperature of 306.0 K?

$$C_5H_{12}\,(g) + 8\,O_2\,(g) \rightarrow 5\,CO_2\,(g) + 6\,H_2O\,(g)$$

1396 L ← ②

12.000 mol —①→ 60.000 mol

① $12.000\ \text{mol}\ C_5H_{12}\left(\frac{5\ \text{mol}\ CO_2}{1\ \text{mol}\ C_5H_{12}}\right) = 60.000\ \text{mol}\ CO_2$

② $V = \frac{nRT}{P} = \frac{(60.000\ \text{mol})\left(0.0821\ \frac{\text{L·atm}}{\text{mol·K}}\right)(306.0\ \text{K})}{(1.080\ \text{atm})} = 1396\ \text{L}$

(A) 120.0 L of CO_2 are formed
(B) 1396 L of CO_2 are formed
(C) 60.00 L of CO_2 are formed
(D) 44.01 L of CO_2 are formed
(E) 8.20×10^{-3} L of CO_2 are formed

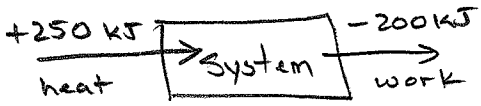
11. A student places 2.00 moles of Xe (g) and 6.00 moles of O_2 (g) into a flask at 298 K and measures the pressure to be 8.00 atm. The pressure due to Xe (g) is:

(A) 1.00 atm
(B) 2.00 atm
(C) 4.00 atm
(D) 0.333 atm
(E) 0.667 atm

$$P_{Xe} = \chi_{Xe} P_{TOT} = \left(\frac{\text{part}\ 2.00\ \text{mol}}{\text{whole}\ 8.00\ \text{mol}}\right)(8.00\ \text{atm}) = 2.00\ \text{atm}$$

12. A system takes in 250 kJ of heat and does 200 kJ of work. The change in the internal energy of the system is:

(A) + 50 kJ
(B) - 50 kJ
(C) + 450 kJ
(D) - 450 kJ
(E) + 50,000 kJ



$\Delta E = q + w = (+250\ kJ) + (-200\ kJ) = +50\ kJ$

13. Which of the following processes is exothermic?

(A) $16\ CO_2\ (g) + 18\ H_2O\ (g) \rightarrow 2\ C_8H_{18}\ (l) + 25\ O_2\ (g)$
(B) $H_2O\ (s) \rightarrow H_2O\ (l)$
(C) $H_2O\ (l) \rightarrow H_2O\ (g)$
(D) $NH_4NO_3\ (s) \rightarrow NH_4NO_3\ (aq)$
(E) $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$

Combustion

14. How much heat is required to raise the temperature of 90.0 grams of water from 19.0°C to 89.0°C?

(A) 152,190 kJ
(B) 152 kJ
(C) 6.30 kJ
(D) 30.9 kJ
(E) 26.3 kJ

$q = mc\Delta T = (90.0g)(4.18\ \frac{J}{g \cdot °C})(89.0°C - 19.0°C)$

$= 26.3\ kJ$

15. How much heat is required to vaporize 255 grams of ethanol?

(A) 0.500 kJ
(B) 1130 kJ
(C) 2090 kJ
(D) 217 kJ
(E) 221 kJ

$q = m H_{vap} = (255\ g)(852\ \frac{J}{g})$

$= 217\ kJ$

16. The heat of formation ($\Delta H°_f$) of $CH_3CH_2CH_2CH_2OH$ (l) is –289.2 kJ/mol. The chemical equation associated with this reaction is:

(A) $CH_3CH_2CH_2CH_2OH\ (l) + 6\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 5\ H_2O\ (g)$
(B) $CH_3CH_2CH_2CH_2OH\ (l) + 13/2\ O_2\ (g) \rightarrow 4\ CO_2\ (g) + 5\ H_2O\ (g)$
(C) $4\ C\ (s, graphite) + ½\ O_2\ (g) + 5\ H_2\ (g) \rightarrow CH_3CH_2CH_2CH_2OH\ (l)$ elements → 1 mol compound
(D) $4\ CO_2\ (g) + 5\ H_2O\ (g) \rightarrow CH_3CH_2CH_2CH_2OH\ (l) + 6\ O_2\ (g)$
(E) $CH_3\ (g) + CH_2\ (g) + CH_2\ (g)\ CH_2\ (g) + ½\ O_2\ (g) + ½\ H_2\ (g) \rightarrow CH_3CH_2CH_2CH_2OH\ (l)$

17. Use the data in the table below to answer the following question:

$\Delta H°_f$	(kJ/mol)
CO_2 (g)	−393.5
C_6H_6 (g)	+ 49.0
H_2O (l)	−285.9

What is $\Delta H°_{reaction}$ for the following reaction?

$$C_6H_6\ (l) + 15/2\ O_2\ (g) \rightarrow 6\ CO_2\ (g) + 3\ H_2O\ (l)$$

$+49.0\ \frac{kJ}{mol}$ $\quad 0\ \frac{kJ}{mol}$ $\quad -393.5\ \frac{kJ}{mol}$ $\quad -285.9\ \frac{kJ}{mol}$

$\Delta H°_{rxtn} = \Sigma products - \Sigma reactants = \left[(6\ mol\ CO_2)(-393.5\ \frac{kJ}{mol}) + (3\ mol\ H_2O)(-285.9\ \frac{kJ}{mol})\right] -$
$\left[(1\ mol\ C_6H_6)(+49.0\ \frac{kJ}{mol}) + (\frac{15}{2}\ mol\ O_2)(0\ \frac{kJ}{mol})\right] =$

$-3268\ kJ$

(A) +335 kJ.
(B) -335 kJ.
(C) -3268 kJ.
(D) -6535 kJ.
(E) -8368 kJ.

18. Consider:

$$2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (l)\ \Delta H^\circ_{reaction} = -10900\ kJ$$

How much energy is released when 40.000 moles of octane, C_8H_{18}, is combusted?

(A) 10900 kJ
(B) 21800 kJ
(C) 32700 kJ
(D) 43600 kJ
(E) 218000 kJ

$$40.000\ mol\ C_8H_{18}\left(\frac{-10900\ kJ}{2\ mol\ C_8H_{18}}\right) = -218{,}000\ kJ$$

218,000 kJ are released

19. Which of the following statements is correct (data are provided on the cover pages)?

(A) It takes more heat to vaporize 100 grams of water at 100 °C than to melt 100 grams of water at 0 °C.

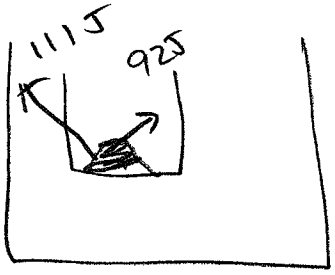
(B) It takes less heat to vaporize 100 grams of water at 100 °C than to melt 100 grams of water at 0 °C.

$H_{vap} = 2260\ \frac{J}{g}$ (Huge)

$H_{fus} = 334\ \frac{J}{g}$

20. A student dissolves 80.0 grams of a solid into 2000.0 grams of water in a calorimeter. The solution takes in 92 J of heat and the calorimeter takes in 111 J of heat. How much heat was released from the reaction when the solid was dissolved?

(A) 203 J
(B) 19 J
(C) 5075 J
(D) 10.2 J
(E) 10212 J



heat released = 92 J + 111 J = 203 J

21. Determine $\Delta H°$ for: $H_2CO_3\ (aq) \rightarrow H_2O\ (l) + CO_2\ (g)$
using the following two equations:

Flip (1) $H_2CO\ (aq) + O_2\ (g) \rightarrow H_2CO_3\ (aq)$ $\Delta H_1° = -112$ kJ

Flip (2) $H_2O\ (l) + CO_2\ (g) \rightarrow H_2CO\ (aq) + O_2(g)$ $\Delta H_2° = +50$ kJ

Same

(1') $H_2CO_3(aq) \rightarrow H_2CO(aq) + O_2(g)$ $\Delta H_1'^{\circ} = +112$ kJ

(2') $O_2(g)\ H_2CO(aq) \rightarrow H_2O(l) + CO_2(g)$ $\Delta H_2'^{\circ} = -50$ kJ

$H_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g)$ $+62$ kJ

(A) - 162 kJ
(B) + 162 kJ
(C) - 62 kJ
(D) + 62 kJ
(E) - 5600 kJ

22. Which of the following ionic compounds is **insoluble** in water?

(A) $NaNO_3$ ✓
(B) NH_4NO_3 ✓
(C) Li_3PO_4 ✓
(D) $Na(CO_3)_2$ ✓
(E) $CaCO_3$

CO_3^{2-} are insoluble
Ca^{2+} is NOT in Rule 1

23. A student mixes an aqueous solution of $Ca(NO_3)_2$ (aq) with an aqueous solution of Li_2S (aq). Which of the following statements is **FALSE**?

(A) NO_3^- is a spectator ion True
(B) Li^+ is a spectator ion True
(C) Ca^{2+} ions will combine with S^{2-} ions will form the insoluble CaS (s) True
(D) Li^+ ions will combine with NO_3^- ions will form the insoluble $LiNO_3$ (s)

Li^+ and NO_3^- are spectator ions - Rule 1 - soluble

24. Consider the mixture of two aqueous solutions: one of potassium phosphate and one of calcium nitrate. The net ionic equation for the process that occurs is:

(A) Ca^{2+} (aq) + 2 NO_3^- (aq) → $Ca(NO_3)_2$ (s)
(B) K^+ (aq) + NO_3^- (aq) → KNO_3 (s)
(C) $3Ca^{2+}$ (aq) + $2PO_4^{3-}$ (aq) → $Ca_3(PO_4)_2$ (s)
(D) 2 K^+ (aq) + 2 NO_3^- (aq) → 2 KNO_3 (s)
(E) 2 K_3PO_4 (aq) + 3 $Ca(NO_3)_2$ (aq) → $Ca_3(PO_4)_2$ (s) + 6 KNO_3 (aq)

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

(A) The CH 121 Final Exam is scheduled for 7:30-9:20am on Tuesday, December 9, 2008
(B) The CH 121 Final Exam is scheduled for 7:30-9:20am on Tuesday, December 9, 2008
(C) The CH 121 Final Exam is scheduled for 7:30-9:20am on Tuesday, December 9, 2008
(D) The CH 121 Final Exam is scheduled for 7:30-9:20am on Tuesday, December 9, 2008
(E) The CH 121 Final Exam is scheduled for 7:30-9:20am on Tuesday, December 9, 2008

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