Chemistry 121	Winter 2006	Oregon State University
Exam 2	March 2, 2006	Dr. Richard Nafshun

Test Form 1

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.

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

Substance	J/g·°C
Water	4.184
Methyl Alcohol	2.549
Ice	2.093
Steam	2.009
Benzene	1.750
Wood (typical)	1.674

Substance	J/g·°C
Soil (typical)	1.046
Air	1.046
Aluminum	0.901
Mercury	0.138
Gold	0.130
Lead	0.128

Name	Charge	Formula
Hydroxide	**1-**	**OH^-**
Cyanide	**1-**	**CN^-**
Nitrate	**1-**	**NO_3^-**
Acetate	**1-**	**CH_3COO^-**
Carbonate	**2-**	**CO_3^{2-}**
Phosphate	**3-**	**PO_4^{3-}**
Hydronium	**1+**	**H_3O^+**
Ammonium	**1+**	**NH_4^+**
Sulfate	**2-**	**SO_4^{2-}**

[Period Table of the Elements Here]

1. How many grams of CO_2 (g) are theoretically produced from 216.45 g of pentane, C_5H_{12} (g), and an excess amount of oxygen?

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

216.45 g → ① → 3.000 mol → ② → 15.000 mol → ③ → 660.17 g

① $216.45\ g\ C_5H_{12} \left(\frac{1\ mol}{72.15\ g} \right) = 3.000\ mol\ C_5H_{12}$

② $3.000\ mol\ C_5H_{12} \left(\frac{5\ mol\ CO_2}{1\ mol\ C_5H_{12}} \right) = 15.000\ mol\ CO_2$

③ $15.000\ mol\ CO_2 \left(\frac{44.011\ g}{1\ mol} \right) = 660.17\ g\ CO_2$

(A) 26.41 g CO_2 (g) are produced.
(B) 132.28 g CO_2 (g) are produced.
(C) 660.17 g CO_2 (g) are produced.
(D) 1082.25 g CO_2 (g) are produced.
(E) 360.75 g CO_2 (g) are produced.

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

(A) $NaNO_3$ soluble — Na^+ NO_3^-
(B) NH_4NO_3 soluble — NH_4^+ NO_3^-
(C) Li_3PO_4 soluble — Li^+
(D) $Na(CO_3)_2$ soluble — Na^+
(E) $CaCO_3$ — insoluble

carbonates, CO_3^{2-}, are insoluble and it is not combined with a species from Rule 1

3. Which of the following ionic compounds is **soluble** in water?

(A) $NaOH$ All sodium salts are soluble
(B) $Al(OH)_3$
(C) $Ca_3(PO_4)_2$ insoluble
(D) $SrCO_3$
(E) $AlPO_4$

4. A student calculates that 340.4 grams of carbon dioxide should theoretically be produced during a process. He actually recovers 302.2 grams of carbon dioxide. What is the percent yield for this process?

(A) 1.126 %.
(B) 11.26 %.
(C) 112.6 %.
(D) 12.64 %.
(E) 88.78 %.

$$\text{Percent Yield} = \frac{\text{actual}}{\text{theoretical}} \cdot 100\% = \left(\frac{302.2\,g}{340.4\,g}\right)(100\%) = 88.78\%$$

5. A student dissolves four moles of Na_2CO_3 into a beaker of water. How many sodium ions are present in the solution?

(A) There are 4.82×10^{24} sodium ions in the beaker.
(B) There are 9.63×10^{24} sodium ions in the beaker.
(C) There are 1.20×10^{24} sodium ions in the beaker.
(D) There are 2.41×10^{24} sodium ions in the beaker.
(E) There are 6.02×10^{23} sodium ions in the beaker.

Na^+ Na^+

CO_3^{2-}

$$4 \text{ mol } Na_2CO_3 \left(\frac{2 \text{ mol } Na^+}{1 \text{ mol } Na_2CO_3}\right)\left(\frac{6.02 \times 10^{23}\ Na^+}{1 \text{ mol } Na^+}\right) = 4.82 \times 10^{24}\ Na^+$$

6. A student mixes two solutions: K_3PO_4 (aq) and $Ca(NO_3)_2$ (aq). The solid precipitate formed is:

(A) KNO_3 (s).
(B) $Ca_3(PO_4)_2$ (s).
(C) KOH (s).
(D) CaO (s).
(E) K_3PO_4 (s).

$$2\ K_3PO_4(aq) + 3\ Ca(NO_3)_2\ (aq) \rightarrow 6\ KNO_3(aq) + \underline{Ca_3(PO_4)_2(s)}$$

insoluble

7. A student obtains a Thermos® bottle 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?

(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. No

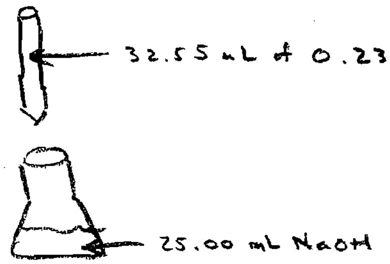
(B) The gases inside the bottle are traveling the same velocity at the higher temperature than at the lower temperature; the pressure inside the bottle is higher at the higher temperature than at the lower temperature; the number of moles of gas present inside the bottle is higher at the higher temperature 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 obtains 25.00 mL of NaOH (aq) of unknown concentration. Upon titration, 32.55 mL of 0.2305 M HCl (aq) are required for neutralization. Determine the concentration of the NaOH (aq).



(A) 3.332 M
(B) 187.57 M
(C) 18.757 M
(D) 0.3001 M
(E) 0.1770 M

At the neutralization point: moles HCl = moles NaOH

$$M_{HCl}V_{HCl} = M_{NaOH}V_{NaOH}$$

$$(0.2305\ M)(32.55\ mL) = (M_{NaOH})(25.00\ mL)$$

$$M_{NaOH} = 0.3001\ M$$

9. A student dilutes 400.0 mL of 1.500 M NaOH to a new volume of 750.0 mL. The concentration of the new solution is:

$$M_{Before}V_{Before} = M_{After}V_{After}$$

(A) 0.8000 M
(B) 1.250 M
(C) 4.500 M
(D) 0.2222 M
(E) 0.3556 M

$$(1.500\ M)(400.0\ mL) = (M_{After})(750.0\ mL)$$

$$M_{After} = 0.8000\ M$$

K = 273.15 + 32 = 305.15 K

K = 273.15 + (-12.0) = 261.15 K

10. A student obtains a 3.25 liter balloon at 32.0 °C. She cools the balloon to –12.0 °C. The volume of the balloon at –12.0 °C is:

$PV = nRT$

(A) 2.78 L
(B) 1.22 L
(C) 0.821 L
(D) 0.360 L
(E) 3.60 L

$$\frac{\cancel{P}V_1}{\cancel{n}\cancel{R}T_1} = \frac{\cancel{P}V_2}{\cancel{n}\cancel{R}T_2} \qquad \frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \frac{3.25\ L}{305.15\ K} = \frac{V_2}{261.15\ K}$$

$$V_2 = 2.78\ L$$

11. 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:

$PV = nRT$

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

$n = 0.0488\ \text{mol}$

$$\text{Molar Mass} = \frac{g}{mol} = \frac{1.854\ g}{0.0488\ mol} = 37.98\ g/mol$$

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

12. A student places 320.0 grams of oxygen gas (O_2) into a 450.0-L flask at 273 K. The pressure inside the flask is:

$$320.0\ g\ O_2 \left(\frac{1\ mol}{32\ g}\right) = 10.0\ mol\ O_2$$

$PV = nRT$

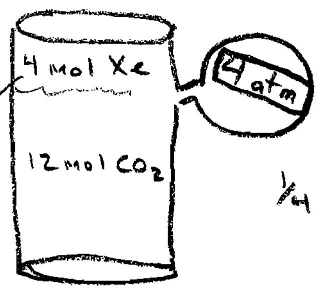
$$P = \frac{nRT}{V} = \frac{(10.0\ \text{mol})(0.0821\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(273\ \text{K})}{450.0\ \text{L}} = 0.498\ \text{atm}$$

(A) 0.0627 atm.
(B) 15.9 atm.
(C) 2.00 atm.
(D) 0.498 atm.
(E) 1.00 atm.

13. A student places 4.00 moles of Xe (g) and 12.00 moles of CO_2 (g) into a flask at 298 K and measures the pressure to be 4.00 atm. The pressure due to Xe (g) is:

(A) 0.250 atm.
(B) 1.00 atm.
(C) 1.33 atm.
(D) 3.00 atm.
(E) 4.00 atm.

$X_{Xe} = \frac{1}{4}$



$\frac{1}{4}$ of 4 atm = 1 atm

14. The root-mean-square speed of He (g) at 0.9330 atm and 273.0 K is:

(A) 434 m/s
(B) 741 m/s
(C) 1304 m/s
(D) 1.70×10^6 m/s
(E) 3.40×10^6 m/s

$$u_{rms} = \sqrt{\frac{3RT}{\text{Molar Mass}}} = \sqrt{\frac{(3)\left(8.314 \frac{kg \cdot m^2}{s^2 \cdot mol \cdot K}\right)(273.0\,K)}{4.00 \times 10^{-3} \frac{kg}{mol}}} = 1304 \frac{m}{s}$$

15. Consider the following five gases: F_2 (g) I_2 (g) He (g) C_2H_4 (g) N_2 (g)

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

(A) ~~F_2 (g)~~
(B) I_2 (g)
(C) ~~He (g)~~
(D) C_2H_4 (g)
(E) N_2 (g).

16. The reaction below takes place in a room (a constant pressure of 1.00 atm and a constant temperature of 293 K for both reactants and products).

$$C_{11}H_{24}\,(g) \quad + \quad 17\,O_2\,(g) \quad \rightarrow \quad 11\,CO_2\,(g) \quad + \quad 12\,H_2O\,(g)$$

7.00 L ⟶ 77.0 L

When 7.00 L of $C_{11}H_{24}$ (g) react,

(A) 3.50 L of CO_2 are formed.
(B) 7.00 L of CO_2 are formed.
(C) 119 L of CO_2 are formed.
(D) 77.0 L of CO_2 are formed.
(E) 84.0 L of CO_2 are formed.

17. Shown below is the balanced equation for the combustion of butane. What is the volume (liters) of CO_2 (g) produced at 1.500 atm and 298.0 K from the combustion of ~~100.0 g~~ 116.24g of butane in excess O_2 (g)?

$$2\ C_4H_{10}\ (g) \quad + \quad 13\ O_2\ (g) \rightarrow \quad 8\ CO_2\ (g) + \quad 10\ H_2O\ (g)$$

116.24 g
① ↓

______ L
↑③

2.00 mol ——②——→ 8.00 mol

① 116.24 g C_4H_{10} $\left(\frac{1\ mol}{58.12\ g}\right)$ = 2.00 mol C_4H_{10}

② 2.00 mol C_4H_{10} $\left(\frac{8\ mol\ CO_2}{2\ mol\ C_4H_{10}}\right)$ = 8.00 mol CO_2

PV = nRT

$V = \frac{nRT}{P} = \frac{(8.00\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(298\ K)}{1.500\ atm} = 130.5\ L$

(A) 125.5 L
(B) 28.08 L
(C) 112.3 L
(D) 224.0 L
(E) ~~140.3~~ L
130.5

18. 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

19. 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) 26.4 kJ

$q = mc\Delta T = (90.0\text{ g})(4.184\text{ J/g}\cdot{}^\circ\text{C})(89.0^\circ\text{C} - 19.0^\circ\text{C})$

$= 26{,}359\text{ J}$ or 26.4 kJ

20. A system takes in 1345 kJ of heat and does 3305 kJ of work. The change in internal energy is:

(A) + 4650 kJ.
(B) - 4650 kJ.
(C) ~~+ 1960 kJ.~~
(D) - 1960 kJ.
(E) ~~+ 4.445 x 10^6 kJ.~~

$\Delta E = w + q = (-3305\text{ kJ}) + (+1345\text{ kJ})$

does work = (−)

takes in = (+)

$= -1960\text{ kJ}$

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

ΔH°_f	(kJ/mol)
CO_2 (g)	−393.5
C_6H_6 (g)	+ 49.0
H_2O (l)	−285.9

What is $\Delta H^\circ_{reaction}$ for the following reaction?

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

+49.0 ∅ −393.5 −285.9

ΔH°_{rxn} = Products − Reactants $= \left[\left((6\text{ mol } CO_2)(-393.5\ \tfrac{kJ}{mol})\right) + \left(3\text{ mol } H_2O)(-285.9\ \tfrac{kJ}{mol}\right)\right] - \left\{\left(1\text{ mol } C_6H_6)(+49.0\ \tfrac{kJ}{mol}\right)\right\} = -3268\text{ kJ}$

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

22. Determine $\Delta H°$ for this reaction:

$$2\ N_2(g) + 5\ O_2(g) \rightarrow 2\ N_2O_5(g)$$

using the following three equations:

becomes

Flip and x2 → (1) $H_2(g) + (1/2)\ O_2(g) \rightarrow H_2O(l)$ $\Delta H_1° = -285.8$ kJ → + 571.6 kJ

Cancel!!

Flip and x2 → (2) $N_2O_5(g) + H_2O(l) \rightarrow 2HNO_3(l)$ $\Delta H_2° = -76.6$ kJ → + 153.2 kJ

Leave → (3) $2\ N_2(g) + 6\ O_2(g) + 2\ H_2(g) \rightarrow 4\ HNO_3(l)$ $\Delta H_3° = -696.4$ kJ → - 696.4 kJ

+ 28.4 kJ

(1') $\cancel{2H_2O} \rightarrow 2\ \cancel{H_2} + \cancel{O_2}$

(2') $\cancel{4HNO_3} \rightarrow 2\ N_2O_5 + \cancel{2H_2O}$

(3) $\boxed{2\ N_2} + \cancel{6}^{5}\ O_2 + \cancel{2H_2} \rightarrow \cancel{4\ HNO_3}$

$2\ N_2 + 5\ O_2 \rightarrow 2\ N_2O_5$

(A) -95.8 kJ.
(B) + ~~371 kJ.~~
(C) +28.4 kJ.
(D) ~~-1059 kJ.~~
(E) +1345 kJ.

23. 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) ~~$\frac{1}{2} N_2\ (g) + 4\ HCl\ (aq) \rightarrow NH_4Cl\ (s) + 3/2\ Cl_2\ (g)$~~
(B) $\frac{1}{2} N_2\ (g) + 2\ H_2\ (g) + \frac{1}{2} Cl_2\ (g) \rightarrow NH_4Cl\ (s)$
(C) ~~$NH_4^+\ (aq) + Cl^-\ (aq) \rightarrow NH_4Cl\ (s)$~~
(D) $NH_4^+\ (s) + Cl^-\ (s) \rightarrow NH_4Cl\ (s)$
(E) $NH_4\ (s) + Cl\ (g) \rightarrow NH_4Cl\ (s)$

Elements → NH_4Cl

24. 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.

$$40.000\ \text{mol}\ C_8H_{18} \left(\frac{10{,}900\ \text{kJ are released for}}{2\ \text{mol}\ C_8H_{18}} \right) = 218{,}000\ \text{kJ are released.}$$

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

(A) The CH 121e Final Exam is 4:00-5:50pm Pacific Time on Tuesday, March 21, 2006.
(B) The CH 121e Final Exam is 4:00-5:50pm Pacific Time on Tuesday, March 21, 2006.
(C) The CH 121e Final Exam is 4:00-5:50pm Pacific Time on Tuesday, March 21, 2006.
(D) The CH 121e Final Exam is 4:00-5:50pm Pacific Time on Tuesday, March 21, 2006.
(E) The CH 121e Final Exam is 4:00-5:50pm Pacific Time on Tuesday, March 21, 2006.