Chemistry 121	Fall 2004	Oregon State University
Exam 2	November 18, 2004	Dr. Richard Nafshun

Test Form 4

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. **Enter the test form number on your Scantron form, but leave the class section 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
$N_A = 6.02 \times 10^{23}$	$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$	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

Periodic Table of the Elements

Key:
- 1 — Atomic number
- H — Symbol
- Hydrogen — Name
- 1.0079 — Atomic mass

Periods	Group IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII	VII	VII	1B	IIB	IIIA	IVA	VA	VIA	VIIA	Noble Gases VIIIA
1	1 H Hydrogen 1.0079																	2 He Helium 4.0026
2	3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984	10 Ne Neon 20.179
3	11 Na Sodium 22.98977	12 Mg Magnesium 24.305											13 Al Aluminum 26.9815	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
4	19 K Potassium 39.0983	20 Ca Calcium 40.08	21 Sc Scandium 44.9559	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.996	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.70	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
5	37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.22	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 98.906	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.30
6	55 Cs Cesium 132.9054	56 Ba Barium 137.33	57–71 *Rare earths	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
7	87 Fr Francium (223)	88 Ra Radium 226.0254	89–103 †Actinides	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (263)	107 Ns Neilsbohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 ‡ (269)	111 ‡			114				

→ Stable region?

		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
*Lanthanides	6	57 La Lanthanium 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium 140.9077	60 Nd Neodymium 144.24	61 Pm Promethium 145	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
†Actinides	7	89 Ac Actinium 227.0278	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359	92 U Uranium 238.029	93 Np Neptunium 237.0482	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium 259	103 Lr Lawrencium 262

Note: The atomic mass value given is for naturally occurring proportions of isotopes. Values in parentheses are mass numbers for the most stable isotope.
‡Reported but not confirmed; no name proposed.

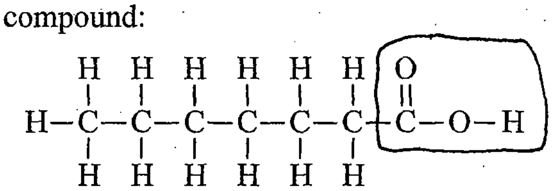
1. Which of the following selections contains only acids?

(A) CH_4, CH_3CH_3, $CH_3CH_2CH_3$, $CH_3CH_2CH_2CH_3$.
(B) HNO_3, $NaNO_3$, HCl, $NaCl$.
(C) $NaOH$, KOH, NH_4OH, $Ca(OH)_2$.
(D) HNO_3, HCl, NH_3.
(E) H_2SO_4, HNO_3, HCl, CH_3COOH.

2. Consider fuel cells. Which of the following is **false**?

(A) A hydrogen fuel cell produces energy.
(B) The hydrogen fuel cell demonstrated in class produced water.
(C) The hydrogen fuel cell demonstrated in class contains platinum to facilitate the process.
(D) The fuel cell consists of tiny chambers that allow hydrogen gas to explode.
(E) The hydrogen fuel cell demonstrated in class used hydrogen and oxygen gases.

3. Consider the following compound:



The compound is:

(A) a strong acid.
(B) a weak acid.
(C) a strong base.
(D) a weak base.

$-\overset{O}{\overset{\|}{C}}-O-H$

carboxylic acid group (weak acid)

4. A student places 116.9 grams of NaCl (s) into a 1.000-L volumetric flask and then fills to the mark with water. This is Solution #1. The student then dilutes 0.5000 liters of Solution #1 to a total volume of 1.000 liter. This is Solution #2.

(A) The concentration of Solution #1 is 116.9 M; the concentration of Solution #2 is 233.8 M.
(B) The concentration of Solution #1 is 116.9 M; the concentration of Solution #2 is 58.45 M.
(C) The concentration of Solution #1 is 2.000 M; the concentration of Solution #2 is 1.000 M.
(D) The concentration of Solution #1 is 2.000 M; the concentration of Solution #2 is 2.000 M.
(E) The concentration of Solution #1 is 2.000 M; the concentration of Solution #2 is 4.000 M.

Solution #1 $M = \frac{mol}{L} = \frac{\left(\frac{116.9\ g\ NaCl}{58.45\ g/mol}\right)}{1.000\ L} = 2.000\ M$

Solution #2 $M_1V_1 = M_2V_2$ $(2.000\ M)(0.5000\ L) = (M_2)(1.000\ L)$

$M_2 = 1.000\ M$

5. A student calculates that 120.04 grams of carbon dioxide should theoretically be produced from the combustion of propane during a process. She actually recovers 112.5 grams of carbon dioxide. What is the percent yield for this process?

(A) 7.540 %.
(B) 6.281 %.
(C) 6.700 %.
(D) 93.72 %.
(E) 17.54 %.

Percent Yield = $\left(\frac{\text{Actual}}{\text{Theoretical}}\right)(100\%)$

$= \left(\frac{112.5 \text{ g}}{120.04 \text{ g}}\right)(100\%) = 93.72\%$

6. What is the mass percent composition of ethanol, C_2H_6O?

(A) %C = 52.14%; %H = 13.13%; %O = 34.73%
(B) %C = 33.33%; %H = 33.33%; %O = 33.33%
(C) %C = 22.22%; %H = 66.67%; %O = 11.11%
(D) %C = 2.22%; %H = 6.67%; %O = 1.11%
(E) %C = 26.07%; %H = 2.18%; %O = 69.46%

$2\ C = 2 \times 12.011 \frac{g}{mol} = 24.022 \frac{g}{mol}$

$6\ H = 6 \times 1.0079 \frac{g}{mol} = 6.047 \frac{g}{mol}$

$1\ O = 1 \times 16.00 \frac{g}{mol} = 16.00 \frac{g}{mol}$

$C_2H_6O = 46.069\ g/mol$

$\%C = \frac{24.022\ g/mol}{46.069\ g/mol} = 52.14\%$

$\%H = \frac{6.047\ g/mol}{46.069\ g/mol} = 13.13\%$

$\%O = 16\ g/mol / 46.069\ g/mol = 34.73\%$

7. How many grams of H_2O (g) are produced from 440.96 g of propane and excess oxygen?

$C_3H_8(g) + 5\ O_2(g) \rightarrow 3\ CO_2(g) + 4\ H_2O(g)$

440.96 g ↓ ① 10.000 Mol ——②——→ 40.000 Mol ↑ ③ 720.63 g

① $440.96\text{ g } C_3H_8 \left(\frac{1\text{ mol}}{44.096\text{ g}}\right) = 10.000\text{ mol } C_3H_8$

② $10.000\text{ mol } C_3H_8 \left(\frac{4\text{ mol } H_2O}{1\text{ mol } C_3H_8}\right) = 40.000\text{ mol } H_2O$

③ $40.000\text{ mol } H_2O \left(\frac{18.016\text{ g}}{1\text{ mol}}\right) = 720.63\text{ g } H_2O$

(A) 1763.8 g H_2O (g) are produced.
(B) 44.096 g H_2O (g) are produced.
(C) 720.63 g H_2O (g) are produced.
(D) 10.000 g H_2O (g) are produced.
(E) 180.16 H_2O (g) are produced.

8. 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).

Net Ionic Equation:

$3\,Ca^{2+}(aq) + 2\,PO_4^{3-}(aq) \rightarrow Ca_3(PO_4)_2(s)$

The phosphate ion is insoluble (except when exclusively in the presence of a group 1A metal or ammonium ion.

9. A student obtains 25.00 mL of an HCl solution of unknown concentration. Upon titration, 18.74 mL of 0.09950 M NaOH are required for neutralization. Determine the concentration of the HCl solution.

$HCl + NaOH \rightarrow NaCl + H_2O$

(A) 18.74 M.
(B) 0.07459 M.
(C) 13.41 M.
(D) 0.1327 M.
(E) 7.534 M.

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

$(M_{HCl})(25.00\text{ mL}) = (18.74\text{ mL})(0.09950\text{ M})$

$M_{HCl} = 0.07459\text{ M}$

10. A student obtains a 2.00 liter balloon at 20.0 °C. He cools the balloon to –20.0 °C. The volume of the balloon at –20.0 °C is:

(A) 1.00 L.
(B) -2.00 L.
(C) 1.16 L.
(D) 2.32 L.
(E) 1.73 L.

$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$

Balloon - constant P
Closed container - constant n

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\qquad \frac{2.00\text{ L}}{293.15\text{ K}} = \frac{V_2}{253.15\text{ K}}$ $\qquad V_2 = 1.73\text{ L}$

11. A student places 64.00 grams of oxygen gas (O_2) into a 3.000-L flask at 293.15 K. The pressure inside the flask is:

(A) 513.4 atm.
(B) 35.03 atm.
(C) 16.05 atm.
(D) 7.978 atm.
(E) 0.2493 atm.

$PV = nRT$

$$P = \frac{nRT}{V} = \frac{\left(\frac{64.00\text{ g}}{32.00\text{ g/mol}}\right)\left(0.0821\frac{L\cdot atm}{mol\cdot K}\right)(293.15\text{ K})}{3.000\text{ L}}$$

$= 16.05$ atm

12. A student places 2.00 moles of O_2 (g) and 4.00 moles of CH_4 (g) into a 44.8-L flask at 273 K. The pressure of CH_4 (g) is:

(A) 1/3 atm.
(B) 1.00 atm.
(C) 2.00 atm.
(D) 3.00 atm.
(E) 2/3 atm.

$$P_{CH_4} = \frac{n_{CH_4} RT}{V} = \frac{(4.00\ mol)(0.0821\ \frac{L \cdot atm}{mol \cdot K})(273\ K)}{(44.8\ L)} = 2.00\ atm$$

13. The root-mean-square speed of F_2 (g) at 1.00 atm and 293 K is:

(A) 13.9 m/s.
(B) 439 m/s.
(C) 514 m/s.
(D) 1191 m/s.
(E) 192 m/s.

$$u_{rms} = \sqrt{\frac{3RT}{\text{Molar Mass}}} = \sqrt{\frac{(3)(8.314\ \frac{kg \cdot m^2}{s^2 \cdot mol \cdot K})(293\ K)}{38 \times 10^{-3}\ \frac{kg}{mol}}} = 438.54\ \frac{m}{s} = 439\ \frac{m}{s}$$

14. Consider the following five gases: H_2 (g) CO_2 (g) Ar (g) SF_6 (g) Cl_2 (g)

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

↳ Lightest

(A) H_2 (g).
(B) CO_2 (g).
(C) Ar (g).
(D) SF_6 (g).
(E) Cl_2 (g).

15. The reaction below takes place in a classroom (a constant pressure of 1.00 atm and a constant temperature of 273 K for both reactants and products).

$$C_3H_8\,(g) \quad + \quad 5\,O_2\,(g) \quad \rightarrow \quad 3\,CO_2\,(g) \quad + \quad 4\,H_2O\,(g)$$

2.00 L ⟶ 6.00 L

$2.00\text{ L } C_3H_8 \left(\frac{3\text{ L } CO_2}{1\text{ L } C_3H_8}\right) = 6.00\text{ L } CO_2$

When 2.00 L of C_3H_8 (g) react,

(A) 2.00 L of CO_2 are formed.
(B) 3.00 L of CO_2 are formed.
(C) 4.00 L of CO_2 are formed.
(D) 5.00 L of CO_2 are formed.
(E) 6.00 L of CO_2 are formed.

16. A student places 3.388 g of a noble gas into a 2.00-L container at 293 K and measures the pressure to be 1.02 atm. This noble gas is:

$n = \frac{PV}{RT} = \frac{(1.02\text{ atm})(2.00\text{ L})}{(0.0821\frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}})(293\text{ K})} = 0.0848\text{ mol}$

(A) He.
(B) Ne.
(C) Ar.
(D) Kr.
(E) Xe.

Molar Mass $= \frac{g}{mol} = \frac{3.388\text{ g}}{0.0848\text{ mol}} = 39.95\text{ g/mol}$

18
Ar
39.948

17. Consider a sealed balloon containing nitrogen gas. Which of the following is **false**?

(A) When the temperature is increased, the velocity of the gas molecules increases. True
(B) When the temperature is increased, the volume of the balloon increases. True
(C) When the temperature is increased, the moles of gas inside the balloon increases. False
(D) A 22.4-L balloon, at 1.00 atm, and 273.15 K contains one mole of nitrogen gas. True

18. Which of the following processes is endothermic?

(A) $2\ C_8H_{18}\ (l) + 25\ O_2\ (g) \rightarrow 16\ CO_2\ (g) + 18\ H_2O\ (g)$. Combustion - exothermic
(B) $H_2O\ (l) \rightarrow H_2O\ (s)$. Heat leaves the system when the water freezes
(C) $H_2O\ (g) \rightarrow H_2O\ (l)$. Heat leaves the system
(D) $NH_4NO_3\ (s) \rightarrow NH_4NO_3\ (aq)$. "Cold Pack"

19. How much heat is required to raise the temperature of 2500.0 grams of gold from 30.5 °C to 80.0°C?

(A) 76.3 kJ
(B) 517 kJ
(C) 111 kJ
(D) 8.10 kJ
(E) 16.1 kJ

$q = mc\Delta T$
$= (2500.0\ g)(0.130\ \frac{J}{g \cdot °C})(80.0°C - 30.5°C)$
$= 16087.5\ J$
$= 16.1\ kJ$

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20. A system gives off 40 kJ of heat and does 30 kJ of work. The change in the energy of the system is:

(A) -70 kJ.
(B) +70 kJ.
(C) -10 kJ.
(D) + 10 kJ.
(E) 1.33 kJ.

$E = q + w$
$= (-40\ kJ) + (-30\ kJ)$

↑ 40 kJ of heat leaves

↑ 30 kJ of work is done (leaves the system)

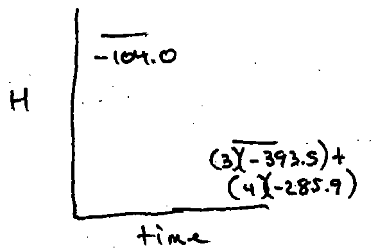
21. Use the data in the table below to answer the following question:

ΔH°_f	(kJ/mol)
CO_2 (g)	- 393.5
C_3H_8 (g)	- 104.0
H_2O (l)	- 285.9

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

$$C_3H_8\,(g) \quad + \quad 5\,O_2\,(g) \quad \rightarrow \quad 3\,CO_2\,(g) \quad + \quad 4\,H_2O\,(l)$$

(1)(-104.0) (5)(0) (3)(-393.5) (4)(-285.9)



ΔH° = products - reactants

$= [(3 \text{ mol } CO_2)(-393.5 \frac{kJ}{mol\,CO_2}) + (4 \text{ mol } H_2O)(-285.9 \frac{kJ}{mol\,H_2O})] - [(1 \text{ mol } C_3H_8)(-104.0 \frac{kJ}{mol}) + (5 \text{ mol } O_2)(0 \frac{kJ}{mol\,O_2})]$

$= -2324.1$ kJ $+ 104.0$ kJ $= 2220.1$ kJ

(A) -783.4 kJ.
(B) -2220.1 kJ.
(C) -2428.1 kJ.
(D) +2428.1 kJ.
(E) + 575.4 kJ.

22. Determine ΔH° for the reaction C(graphite) + 2 H_2(g) → CH_4(g), using:

C(graphite) + O_2(g) → CO_2(g)	ΔH° = -393.5 kJ (1)
H_2(g) + ½ O_2(g) → H_2O(l)	ΔH° = -285.8 kJ (x2)
CH_4(g) + 2 O_2(g) → CO_2(g) + 2 H_2O(l)	ΔH° = -890.3 kJ (-1)
Need C(graphite) + 2 H_2(g) → CH_4(g)	ΔH° = ?

(A) - 105.5 kJ.
(B) - 74.8 kJ.
(C) - 1570 kJ.
(D) - 211.0 kJ.
(E) + 211.0 kJ.

C(graphite) + 1 O_2(g) → CO_2(g)	ΔH° = - 393.5 kJ
2 H_2(g) + 1 O_2(g) → 2 H_2O	ΔH° = (2)(-285.8 kJ)
CO_2(g) + 2 H_2O(l) → CH_4(g) + 2 O_2(g)	ΔH° = + 890.3 kJ
C(graphite) + 2 H_2(g) → CH_4(g)	ΔH° = - 74.8 kJ

23. The heat of formation (ΔH°_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)

$\frac{1}{2} N_2(g) + 2 H_2(g) + \frac{1}{2} Cl_2(g) \rightarrow NH_4Cl \quad \Delta H^\circ_f = -315.4$ kJ

24. When the following reaction is carried out in a flask, the flask feels HOT when held in the hands:

HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O (l) [This reaction is the system]

Which of the following is **TRUE**?

(A) Heat is transferred from the flask to the hand; this is an endothermic reaction.
(B) Heat is transferred from the flask to the hand; this is an exothermic reaction.
(C) Heat is transferred from the hand to the flask; this is an endothermic reaction.
(D) Heat is transferred from the hand to the flask; this is an exothermic reaction.

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

(A) The CH 121 Final Exam is scheduled for Thursday, December 9 at 4:00pm.
(B) The CH 121 Final Exam is scheduled for Thursday, December 9 at 4:00pm.
(C) The CH 121 Final Exam is scheduled for Thursday, December 9 at 4:00pm.
(D) The CH 121 Final Exam is scheduled for Thursday, December 9 at 4:00pm.
(E) ΔH for a process is -322.3 kJ. The process is endothermic.

Hint:
The CH 121 Final Exam is scheduled for Thursday, December 9 from 4:00-5:50pm. Rooms will be assigned and posted near the conclusion of the term. There is no opportunity to reschedule the final exam.