Chemistry 121	Fall 2006	Oregon State University
Exam 2	November 16, 2006	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.

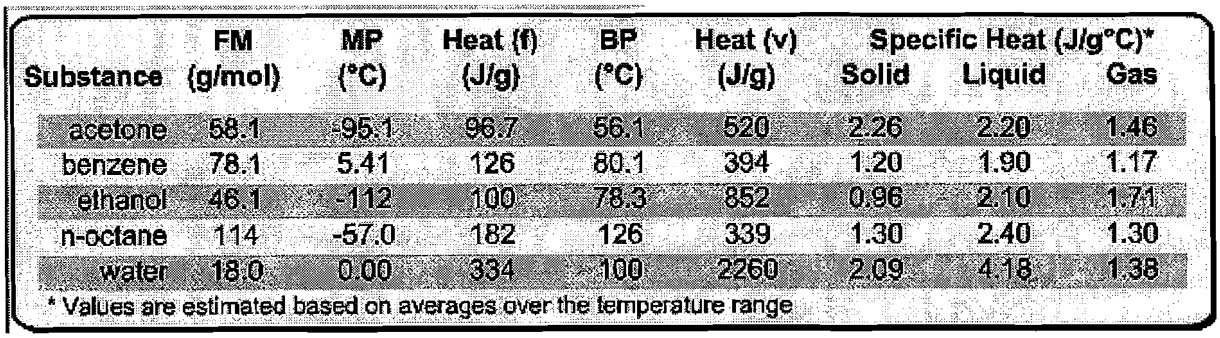
Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. **Leave the class section number and the test form number blank.**

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.

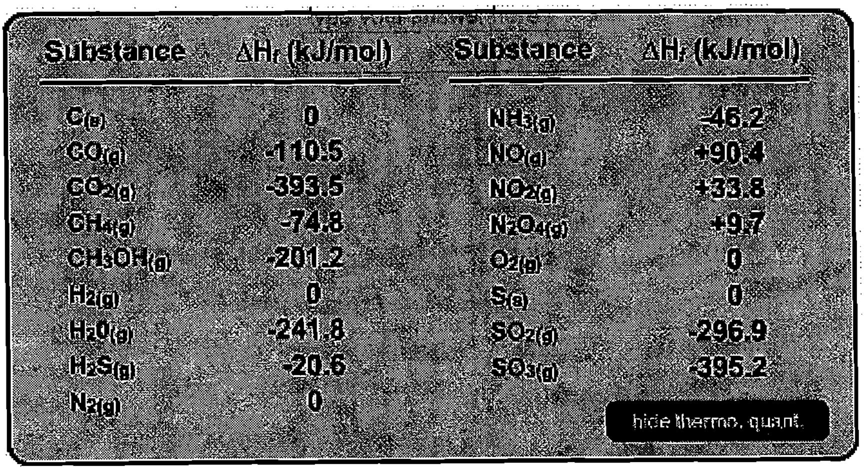
$R = 0.0821 \frac{L \bullet atm}{mol \bullet K}$	$R = 8.314 \frac{kg \bullet m^2}{s^2 \bullet mol \bullet K}$	$\mu_{rms} = \sqrt{\frac{3RT}{Molar\ Mass}}$
PV = nRT	760 Torr = 1 atm = 760 mm Hg	K = 273.15 + °C
1 mole = 6.02×10^{23}	$\frac{P_1V_1}{n_1T_1} = \frac{P_2V_2}{n_2T_2}$	milli (m) = 1/1000 kilo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

1 H Hydrogen 1.0079																	2 He Helium 4.0026
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
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
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
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
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)
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				

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
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

1. 2.50 L of 2.00 M NaCl (aq) is diluted to 4.00 L. What is the molarity of the resulting solution?

(A) 0.200 M
(B) 5.00 M
(C) 20.0 M
(D) 0.800 M
(E) [✓ 1.25 M]

$M_1V_1 = M_2V_2$

$(2.00\text{ M})(2.50\text{ L}) = (M_2)(4.00\text{ L})$

$M_2 = 1.25\text{ M}$

2. A student obtains two solutions. One is 1.00 L of 0.100 M HCl (aq).
The other is 1.00 L of 0.100 M CH_3CH_2COOH (aq).
Which solution contains the most H^+ ions?

(A) [✓ 1.00 L of 0.100 M HCl (aq)] — Strong Acid
(B) 1.00 L of 0.100 M CH_3CH_2COOH (aq) — Weak Acid

$HCl\ (aq) \xrightarrow{100\%} \underline{H^+(aq)} + Cl^-(aq)$

a lot of proton

$CH_3CH_2COOH(aq) \xrightarrow[\text{(Like } 0.2\%)]{\text{Less than } 100\%} CH_3CH_2COO^-(aq) + \underline{H^+(aq)}$

a little proton

3. A student obtains a 25.00 mL sample of HCl (aq). He titrates it with 0.1000 M NaOH (aq) and finds 36.56 mL are required to reach the equivalence point. The concentration of HCl (aq) is:

(A) [✓ 0.1462 M.]
(B) 6.838 M.
(C) 0.06838 M.
(D) 14.62 M.
(E) 91.40 M.

$M_{Acid}V_{Acid} = M_{Base}V_{Base}$

$(M_{Acid})(25.00\text{ mL}) = (0.1000\text{ M})(36.56\text{ mL})$

$M_{Acid} = 0.1462\text{ M}$

4. Which of the following lists contains only acids?

(A) $NaOH$, KOH, NH_4OH, $Ca(OH)_2$
(B) H_2SO_4, HNO_3, HCl, NH_3
[✓ (C) HNO_3, CH_3COOH, CH_3CH_2COOH]
(D) HNO_3, $NaNO_3$, HCl, $NaCl$

HNO_3 - Strong acid

$-COOH$ - weak acids

5. In an excess amount of oxygen, how many grams of CO_2 (g) are theoretically produced from the combustion of 903.0 g of glucose [$C_6H_{12}O_6$ (s), molar mass of 180.2 g/mol]?

$$C_6H_{12}O_6\,(s) \quad + \quad 6\,O_2\,(g) \quad \rightarrow \quad 6\,CO_2\,(g) \quad + \quad 6\,H_2O\,(g)$$

901.0 g ↓ ①

1320 g ↑ ③

5.000 mol $\xrightarrow{②}$ 30.00 mol

① 901.0 g $C_6H_{12}O_6$ $\left(\frac{1 \text{ mol}}{180.2 \text{ g}}\right)$ = 5.000 mol $C_6H_{12}O_6$

② 5.000 mol $C_6H_{12}O_6$ $\left(\frac{6 \text{ mol } CO_2}{1 \text{ mol } C_6H_{12}O_6}\right)$ = 30.00 mol CO_2

③ 30.00 mol CO_2 $\left(\frac{44.01 \text{ g}}{1 \text{ mol}}\right)$ = 1320 g CO_2

(A) 108.1 g CO_2 (g) are produced.
(B) 220.1 g CO_2 (g) are produced.
(C) 264.1 g CO_2 (g) are produced.
[✓ (D) 1320 g CO_2 (g) are produced.]
(E) 4860 g CO_2 (g) are produced.

6. A student calculates that 21.05 grams of lithium fluoride should theoretically be produced during a process. She actually recovers 18.71 grams of lithium fluoride. What is the percent yield for this process?

Percent Yield = $\frac{\text{actual}}{\text{theoretical}}(100\%) = \frac{18.71 g}{21.05 g} \cdot 100\% = 88.88\%$

(A) 92.34 %
(B) 112.5 %
(C) 2.340 %
[✓ (D) 88.88 %]
(E) 1.125 %

7. A student dissolves two moles of $Ca(NO_3)_2$ into a beaker of water. How many nitrate ions are present in the solution?

Ca^{2+} NO_3^- NO_3^-

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

8. A student obtains a 1.038 liter neon light bulb that contains 2.018 grams of neon gas at 298 K. The pressure inside the flask is:

↳ $2.018 g \left(\frac{1 mol}{20.18 g}\right) = 0.1000 mol$

$PV = nRT$

$P = \frac{nRT}{V} = \frac{(0.1000 mol)(0.0821 \frac{L \cdot atm}{mol \cdot K})(298 K)}{1.038 L}$

$P = 2.36 atm$

(A) 0.424 atm
(B) 47.6 atm
(C) 22.4 atm
[✓ (D) 2.36 atm]
(E) 0.624 atm

9. 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.

10. A student places 59.5 g of a gas into a 10.0-L container at 298 K and measures the pressure to be 2.053 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

$$n = \frac{PV}{RT} = \frac{(2.053\ atm)(10.0\ L)}{(0.0821\ \frac{L\cdot atm}{mol\cdot K})(298\ K)} = 0.8391\ mol$$

$$\text{Molar Mass} = \frac{g}{mol} = \frac{59.5\ g}{0.8391\ mol} = 70.9\ g/mol \quad Cl_2$$

11. A student obtains a 5.00 liter sealed Thermos bottle at 304.2 K and 748 mm Hg. She heats the bottle to 382.4 K. The pressure inside the bottle at 382.4 K is:

- (A) [✓ 940 mm Hg]
- (B) 106 mm Hg
- (C) 595 mm Hg
- (D) 1681 mm Hg
- (E) 4700 mm Hg

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

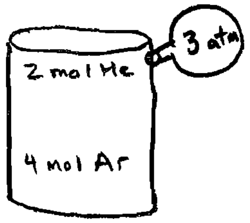
V is constant
n is constant

$$\frac{748\ mm\ Hg}{304.2\ K} = \frac{P_2}{382.4\ K}$$

P_2 = 940 mm Hg

12. A student places 2.00 moles of He (g) and 4.00 moles of Ar (g) into a flask at 298 K and measures the pressure to be 3.00 atm. The pressure due to He (g) is:

- (A) [✓ 1.00 atm]
- (B) 2.00 atm
- (C) 4.00 atm
- (D) 0.333 atm
- (E) 0.667 atm



part

$$\text{Mole Fraction of He} = \frac{2\ mol}{6\ mol} = 1/3$$

whole

$$P_{He} = \frac{1}{3}(3.00\ atm) = 1.00\ atm$$

" $\frac{1}{3}$ of the pressure is due to He "

13. The root-mean-square speed of O_2 (g) in a classroom at 1.062 atm and 294.0 K is:

(A) 229.2 m/s
(B) [✓ 478.7 m/s]
(C) 15.14 m/s
(D) 2.292×10^5 m/s
(E) 47.57 m/s

$$u_{rms} = \sqrt{\frac{3RT}{\text{Molar Mass}}} = \sqrt{\frac{(3)(8.314\ \frac{kg \cdot m^2}{s^2 \cdot mol \cdot K})(294.0\ K)}{32.00 \times 10^{-3}\ \frac{kg}{mol}}}$$

$$= 478.7\ m/s$$

14. Consider the following five gases: Cl_2 (g) I_2 (g) He (g) C_2H_4 (g) Xe (g)

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

↖ lightest

(A) Cl_2 (g)
(B) I_2 (g)
(C) [✓ He (g)] 4 g/mol
(D) C_2H_4 (g)
(E) Xe (g).

15. The reaction below takes place in a room (a constant pressure of 1.072 atm and a constant temperature of 299 K for both reactants and products).

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

$$4.00\ L \xrightarrow{\times 5} 20.00\ L$$

When 4.00 L of C_5H_{12} (g) react,

(A) 22.9 L of CO_2 are formed.
(B) 114 L of CO_2 are formed.
(C) [✓ 20.0 L of CO_2 are formed.]
(D) 5.73 L of CO_2 are formed.
(E) 91.6 L of CO_2 are formed.

16. Which of the following processes is exothermic?

[✓ (A) $2 C_8H_{18} (l) + 25 O_2 (g) \rightarrow 16 CO_2 (g) + 18 H_2O (g)$] Combustion – heat is given off
(B) $H_2O (s) \rightarrow H_2O (l)$ endo
(C) $H_2O (l) \rightarrow H_2O (g)$ endo
(D) $NH_4NO_3 (s) \rightarrow NH_4NO_3 (aq)$ endo ("Cold Pack Reaction")
(E) $CO_2 (s) \rightarrow CO_2 (g)$ endo

17. How much heat is required to raise the temperature of 2510 grams of water from 23.0°C to 99.0°C?

$q = mc\Delta T = (2510 g)(4.18 \frac{J}{g \cdot °C})(99.0°C - 23.0°C)$

$= 797,376 J$ or $797 kJ$

(A) 190,760 kJ
(B) 191 kJ
[✓ (C) 797 kJ]
(D) 76 kJ
(E) 56726 kJ

18. How much heat is required to vaporize 1200 grams of water?

$q = m\Delta H_{vap} = (1200 g)(2260 \frac{J}{g}) =$

$2,712,000 J$ or $2712 kJ$

(A) 1200 kJ
(B) 5016 kJ
(C) 1.200 kJ
(D) 188.3 kJ
[✓ (E) 2712 kJ]

19. A system takes in 3200 kJ of heat and does 4500 kJ of work. The change in the internal energy of the system is:

$\Delta E = q + w = (+3200\ kJ) + (-4500\ kJ)$

Takes in

Does work

$= -1300\ kJ$

(A) + 7700 kJ
(B) - 7700 kJ
(C) [✓ - 1300 kJ]
(D) + 1300 kJ
(E) + 1.440 x 10^7 kJ

20. 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) → 4 CO_2 (g) + 5 H_2O (g)
(B) $CH_3CH_2CH_2CH_2OH$ (l) + 13/2 O_2 (g) → 4 CO_2 (g) + 5 H_2O (g)
(C) [✓ 4 C (s, graphite) + ½ O_2 (g) + 5 H_2 (g) → $CH_3CH_2CH_2CH_2OH$ (l)]
(D) 4 CO_2 (g) + 5 H_2O (g) → $CH_3CH_2CH_2CH_2OH$ (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) → $CH_3CH_2CH_2CH_2OH$ (l)

Elements → Compound

21. [Need to put in answers]

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

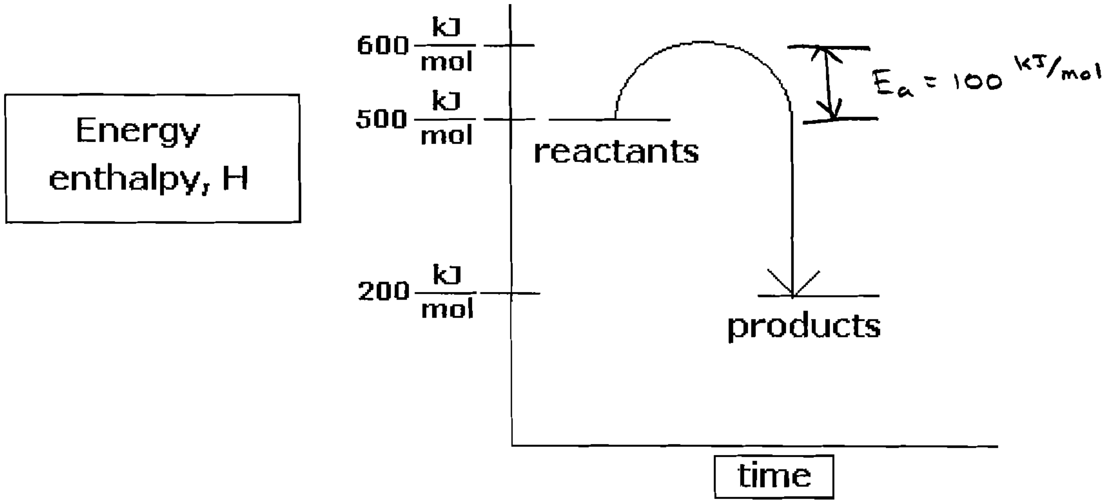
CH_3OH (g)	+	3/2 O_2 (g)	→	CO_2 (g)	+	2 H_2O (g)
$-201.2\ \frac{kJ}{mol}$		$0\ \frac{kJ}{mol}$		$-393.5\ \frac{kJ}{mol}$		$-241.8\ \frac{kJ}{mol}$

$$\Delta H°_{reaction} = \text{products} - \text{reactants} = \{(1\ mol\ CO_2)(-393.5\ \tfrac{kJ}{mol}) + (2\ mol\ H_2O)(-241.8\ \tfrac{kJ}{mol})] - [(1\ mol\ CH_3OH)(-201.2\ \tfrac{kJ}{mol}) + (\tfrac{3}{2}\ mol\ O_2)(0\ \tfrac{kJ}{mol})]\}$$

$$= (-877.1\ kJ) - (-201.2\ kJ) = -675.9\ kJ$$

(A) -877.1 kJ
(B) -74.8 kJ
(C) +877.1 kJ
(D) [✓ -675.9 kJ]
(E) 0 kJ

22. Consider the reaction profile:



The activation energy (E_a) for the process is:

(A) [✓ 100 kJ/mol]
(B) 300 kJ/mol
(C) 400 kJ/mol
(D) 500 kJ/mol
(E) 600 kJ/mol

23. Consider:

For every 1 mole

$$\underline{1}\,C_{12}H_{22}O_{11}\,(s) + 12\,O_2\,(g) \rightarrow 12\,CO_2\,(g) + 11\,H_2O\,(g) \qquad \Delta H^\circ_{reaction} = -5644\text{ kJ}$$

How much energy is released when 6 moles of sucrose, table sugar, $C_{12}H_{22}O_{11}$ (s) is combusted?

(A) 22576 kJ
(B) [✓ 33864 kJ]
(C) 67728 kJ
(D) 135456 kJ
(E) 11288 kJ

$$6\text{ mol}\left(\frac{-5644\text{ kJ}}{1\text{ mol}}\right) = -33,864\text{ kJ}$$

33,864 kJ is released

24. Determine ΔH° for: $2\ S(s) + 3\ O_2(g) \rightarrow 2\ SO_3(g)$ using the following three equations:

2 X (1) $S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H_1° = -296.9$ kJ

Keep (2) $2\ SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\Delta H_2° = -196.0$ kJ

$2\ S(s) + 2\ O_2(g) \rightarrow \cancel{2\ SO_2(g)}$ $\Delta H_1° = -296.9\text{ kJ} * 2 = -593.8\text{ kJ}$

$\cancel{2\ SO_2(g)} + O_2(g) \rightarrow 2\ SO_3(g)$ $\Delta H_2° = -196.0\text{ kJ} = -196.0\text{ kJ}$

$2\ S(s) + 3\ O_2(g) \rightarrow 2\ SO_3(g)$ $\Delta H° =$ -789.8 kJ

(A) - 492.9 kJ
(B) + 492.9 kJ
(C) + 100.9 kJ
(D) [✓ - 789.8 kJ]
(E) 0 kJ

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

ANY

(A) The CH 121 Final Exam is Wednesday, December 6, 2006; 7:30-9:20am (Good Morning!)
(B) The CH 121 Final Exam is Wednesday, December 6, 2006; 7:30-9:20am (Good Morning!)
(C) The CH 121 Final Exam is Wednesday, December 6, 2006; 7:30-9:20am (Good Morning!)
(D) The CH 121 Final Exam is Wednesday, December 6, 2006; 7:30-9:20am (Good Morning!)
(E) The CH 121 Final Exam is Wednesday, December 6, 2006; 7:30-9:20am (Good Morning!)