2004 Exam

Chemistry in Context

Exam 2

Name Key

1. If two different fuels are placed in an alcohol burner like we used in the laboratory and 10.2 grams of fuel A raise the temperature of 100.0 g of water 2.0 degrees C and 9.5 grams of fuel B raise the temperature of 100.0 g of water 4.0 degrees C, what is the energy content (kcal/g) of fuels A and B? Which might make a better fuel and how might density (g/mL) come into this consideration? (8 pts)

A

heat = $\Delta T \cdot m \cdot 1\ cal/g\,C^\circ$

$= (2.0^\circ C)(100\ g)(1\ cal/g^\circ C)$

$= 200\ cal$

$200\ cal = \frac{0.2\ kcal}{10.2\ g} = 0.0196\ kcal/g$ or $19.6\ cal/g$

B

$(4)(100)(1) = 400\ cal/9.5\ g = 42.1\ cal/g$ or $0.042\ kcal/g$

B would be a better fuel because it has a high energy content. Density would be important because it determines the mass of fuel in a given volume (like a gas tank)

2. Write out the combustion reaction for ethanol, CH_3CH_2OH. (3 pts)

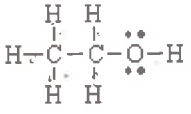
$$CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

3. This is the Lewis structure for ethanol, C_2H_5OH. Calculate the energy change associated with breaking all of the bonds in ethanol. (4 pts)

does not ask about combustion so I just did bonds breaking not the reaction

C-C = 356 kJ/mol C-H = 416 C-O = 336 O-H = 467

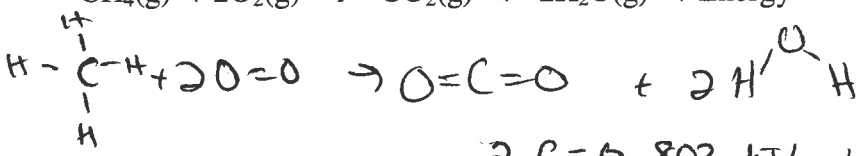
O=O : 498 C=O : 803



5	C-H	416	2080
1	C-C	356	356
1	C-O	336	336
1	O-H	467	467
			3239 kJ/md

4. Using chemical bond energies, determine the Energy (kJ/mol) term for the below combustion reaction. (~~1 kcal/mole = 4.184 kJ/mole~~) (6 pts)

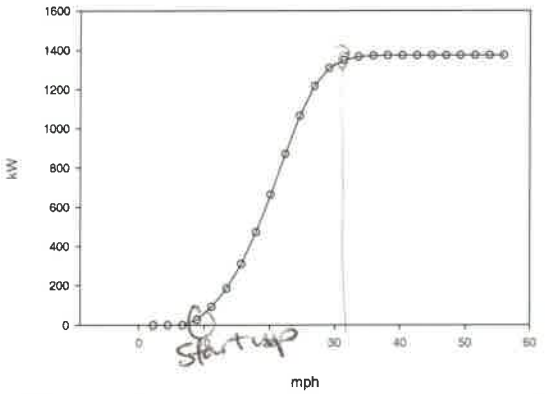
$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) + \text{Energy}$



4 C-H 416 kJ/mol
2 O=O 498 kJ/mol
2 C=O 803 kJ/mol
2 O-H 467 kJ/mol

$4(416) + 2(498) - 2(803) - 2(467) = 120 \text{ kJ/mol}$

5. Wind Energy Calculations (10 pts)



a. What is the approximate start-up speed for the above turbine? ~9 mph

b. At what wind speed is this turbine at peak capacity? ~31 mph

c. How many kW can this turbine produce at peak capacity? 1400 kW

d. If the average capacity factor for this turbine was 25% in St Peter (i.e. over the year it averages 25% of its peak capacity), how many kWh would this turbine produce in one year?

$0.25 \times 1400 \text{ kW} = 350 \text{ kW}$

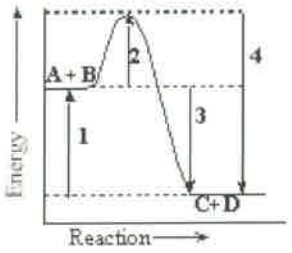
$8760 \text{ hr} \approx 1 \text{ yr}$ so $(350 \text{ kW})(8760 \text{ hr}) = 3066000 \text{ kWh}$

e. If you could sell this electricity at \$0.07/kWh, how much money could you earn in one year?

$(\$0.07/\text{kWh})(3066000 \text{ kWh}) = \$214,620$

6. Which line segment in the diagram represents the net energy change for this reaction? A + B ----> C + D (3 pts)

3



7. Complete the following table: (8 pts)

Name	Chemical Formula	Cation	Anion
Sodium Chloride	NaCl	Na^+	Cl^-
Potassium Hydroxide	KOH	K^+	OH^-
Sodium Sulfate	Na_2SO_4	Na^+	SO_4^{2-}
Magnesium Phosphate	$Mg_3(PO_4)_2$	Mg^{2+}	PO_4^{3-}
Ferric Chloride	$FeCl_3$	Fe^{3+}	Cl^-
Aluminum Hydroxide	$Al(OH)_3$	Al^{3+}	OH^-
Ammonium Nitrate	NH_4NO_3	NH_4^+	NO_3^-

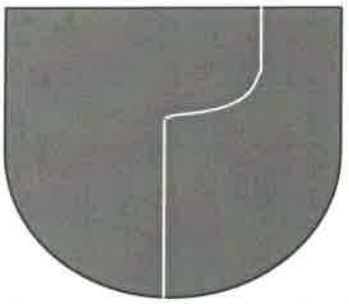
8. Explain why water is a liquid at room temperature, while other molecules like oxygen and nitrogen are gases. (4 pts)

Water can hydrogen bond and it takes a lot of energy to break the inter molecular bonds and boil water. N_2 + O_2 can't hydrogen bond.

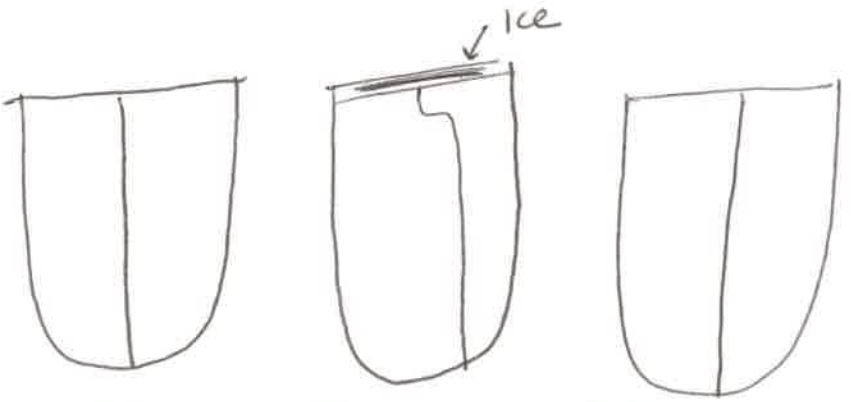
9. Explain why an aqueous solution of NaCl conducts electricity while a solution of sugar does not. (4 pts)

NaCl is ionic and dissociates when placed in water. Sugar does not.

10. Lake stratification (9 pts)



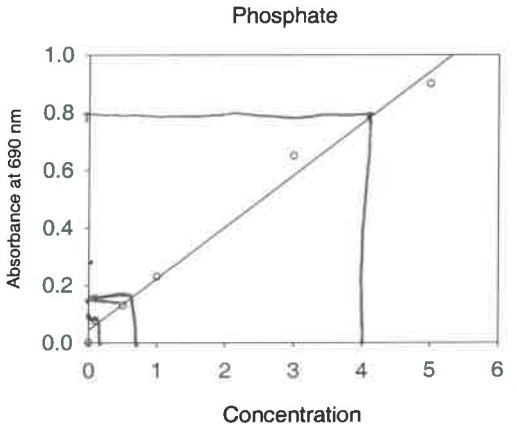
Summer Temperature Profile

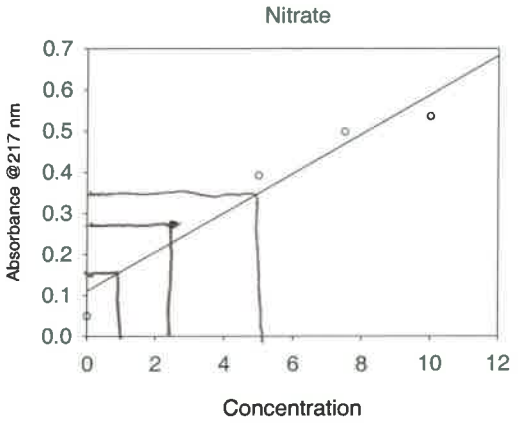


Fall *Winter* *Spring*

Above is a typical temperature profile for a stratified lake in Minnesota. Draw typical temperature profiles for fall, winter, and spring. Briefly explain each profile.

the white line in the summer profile is the temperature. At the top of the lake, there is a layer of warm water. In the fall, there is a time when the temperature is the same in the entire lake. In the winter, ice forms on top of the lake + right below the ice is cold water. The warmer water is at bottom. In the spring, the temperature is the same in the entire lake.





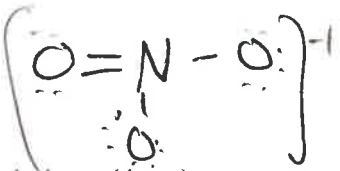
11. Given the following absorbance readings determine approximate concentrations (10 pts)

Sample	NO_3 absorbance	NO_3 concentration	PO_4 absorbance	PO_4 concentration
Treatment Plant Influent	0.35	5	0.8	4
Treatment Plant Effluent	0.15	1	0.18	0.8
MN River Water	0.28	2.2	0.10	0.1

a. Give a possible explanation for the trend in phosphate concentrations that were observed.

The influent had a lot of phosphate but the treatment plant removed most of it.

b. Draw a Lewis dot structure for nitrate NO_3^-



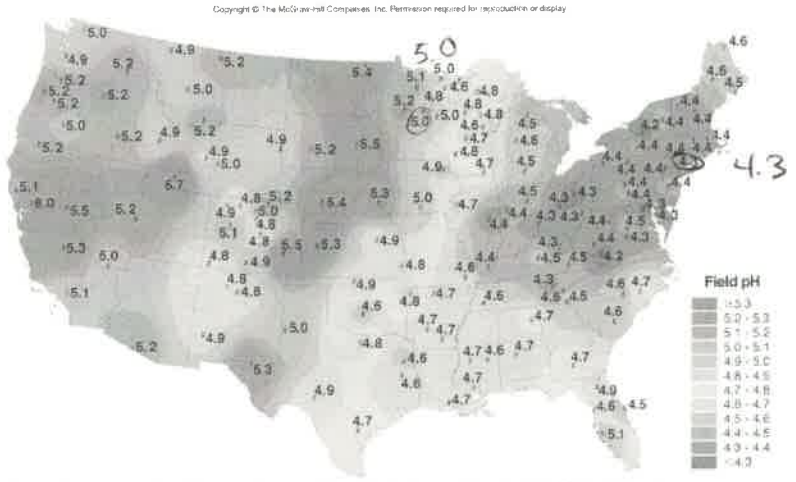
N: 5 e⁻
O: 6 e⁻ × 3 = 18
−: 1 e⁻
24 e⁻

12. Fill in the table below: (4 pts)

$[H^+]$ M	$[OH^-]$ M	pH	pOH
10^{-7}	10^{-7}	7	7
$10^{-5.6}$	$10^{-8.4}$	5.6	8.4
10^{-11}	10^{-3}	11	3

13. (8 pts)

a. How many times more acidic is the rain in New York City (just south of West Point which we examined in class) than in a typical location in Minnesota using the map below. State your answer in terms of concentration of H^+ in mole/L (M).



(Source: National Atmospheric Deposition Program National Trends Network. Taken from http://nadp.sws.uiuc.edu)

$pH = 5$

$[H^+] = 10^{-pH} = 10^{-5}$

$pH = 4.3$

$[H^+] = 10^{-4.3} = 5 \times 10^{-5}$

The pH in New York city is 5 times more acidic.

b. Explain the difference in acidity of the rain in the two locations

There is more industry on the east coast producing NO_x + SO_x.

c. Explain why natural, unpolluted rainwater is more acidic than de-ionized water. How does this relate to the taste of a glass of water left out over night?

CO_2 in rainwater makes it acidic. Overnight some CO_2 partions to glass of water.

14. How does burning coal result in acid rain? Explain what chemical is actually released from the stack and what chemicals eventually fall as acid rain. (4 pts)

burning coal releases SO_x... it is released as SO_2 which is oxidized in the atmosphere to SO_3. SO_3 reacts with water to form H_2SO_4, sulfuric acid.

15. Write a balance equation for the destruction of limestone ($CaCO_3$) with acid rain (H^+) (4 pts)

$$CaCO_3 + H^+ \longrightarrow Ca^{2+} + H_2O + CO_2$$

17. Comment on the following letters to the editor with reference to our class discussions and your scientific knowledge. (6 pts)

For Cleaner Air in the Land of the Free (3 Letters)

New York Times: Published: April 24, 2004

To the Editor:

David Brooks ("Clearing the Air," column, April 20) suggests that the Bush administration "could have moved aggressively to find another way forward" when it became clear that the Kyoto treaty to limit greenhouse gas emissions "was never going to be ratified by the Senate."

In fact, under President Bush's policies, the United States is leading the world in initiatives to curb the growth of greenhouse gas emissions, particularly in the development of new energy technologies that will also reduce America's dependence on foreign oil.

These efforts include developing hydrogen fuel technologies designed to replace gasoline with pollution-free hydrogen; carbon sequestration technologies to remove greenhouse emissions from coal and other fossil fuels; efforts to make nuclear power, which produces no greenhouse gases, safer and more economical; research into nuclear fusion as a power source for the future; the FutureGen project to develop a coal-fired power plant that emits no pollutants or greenhouse gases; and incentives to expand the use of renewable energy sources like wind and solar.

SPENCER ABRAHAM
Secretary of Energy
Washington, April 22, 2004

To the Editor:

David Brooks writes (column, April 20) that a Congressional coalition is blocking the Bush administration's cap-and-trade reforms to the Clean Air Act to prevent a political victory. In fact, there are major differences among competing proposals from the administration and leading members of Congress.

In a research paper, we found that all the proposals — which all embrace cap-and-trade schemes — would yield more benefits than costs, but some more so than others. Most important, the proposals differ significantly on the timing of pollution reductions.

The Bush administration proposal would achieve most of its emission reductions a decade or more later, leading to tens of billions of dollars in additional health costs from