

Chemistry (Environmental Studies) L111
Environmental Concerns and Chemical Solutions
Professor Dransfield

Exam 2
April 5, 2007

Name _____

Student ID Number _____

Statistics

Total Point Available = 200 + 15 bonus

24 Exams Scored

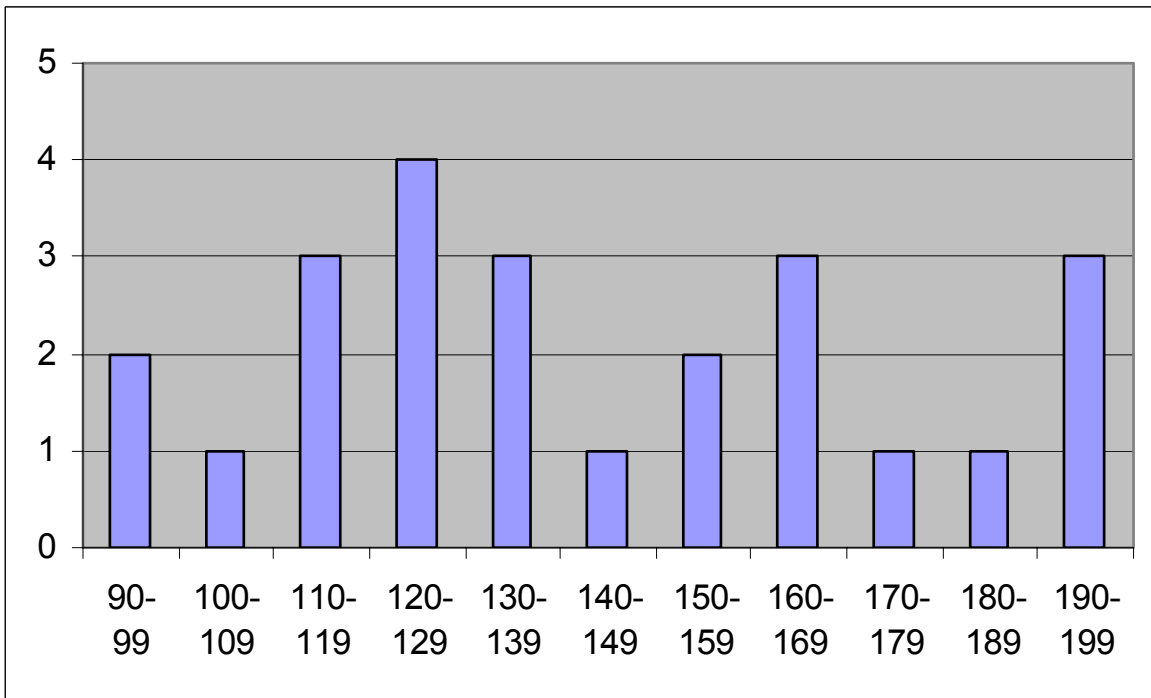
Average = 142

Median = 132

Standard Deviation = 31.7

High = 193

Low = 90



Questions in italic font are from previous quizzes (18/45)

1. Scientists believe they know the average global temperature over the last 160,000 years. Which property of the ice core samples from Antarctica provides this information?

- A. their thickness
- B. their carbon dioxide concentration
- C. their $^1\text{H}/^2\text{H}$ ratio**
- D. their temperature

18/24 answered correctly

2. Which atmospheric component does not contribute to global warming?

- A. H_2O
- B. CO_2
- C. O_3
- D. N_2**

19/24

3. What international agreement attempted to reduce greenhouse gas emissions?

- A. The Kyoto Protocol**
- B. The Montreal Protocol
- C. The Oslo Accords
- D. The Nuremburg Treaty

22/24

4. How many atoms are present in 0.35 mol of carbon dioxide?

- A. 5.81×10^{-25}
- B. 15
- C. 2.11×10^{23}**
- D. 6.32×10^{23}

19/24

5. Predict the geometry of nitrous oxide, N_2O (atomic order N–N–O).

- A. linear**
- B. bent
- C. trigonal pyramidal
- D. trigonal planar

12/24

6. Which explanation accounts for the fact that, on average, cloudy nights are warmer than clear nights?

- A. Clouds reflect light incoming from the moon.
- B. Clouds are composed of water vapor and H_2O is a strong greenhouse gas.**
- C. H_2O does not absorb infrared energy.
- D. Clouds have a high concentration of carbon dioxide from fossil fuel combustion.

17/24

7. Octane (C_8H_{18}) is one of the principal components of gasoline. How many moles of CO_2 are produced during the combustion of 3.0 mol of octane?

- A. 3
- B. 8
- C. 24**
- D. 26

19/24

8. In order to make useful predictions, which factors must be accounted for by climatic models?

- I. Sunspot activity
 - II. Cloud cover
 - III. Volcanic activity
 - IV. Combustion of fossil fuels
- A. IV only
 - B. II and III only
 - C. III and IV only
 - D. I, II III, and IV**

19/24

9. The Intergovernmental Panel on Climate Change (IPCC) issued a report in 2001 which attached probabilities to the predictions and statements made. Which prediction/statement was considered "Very Unlikely"?

- A. The temperatures in the northern hemisphere during the 20th century have been the highest for the past 1,000 years.
- B. The observed warming over the past 100 years is due solely to climatic variability.**
- C. Carbon dioxide contributes to higher global temperatures.
- D. Increased carbon dioxide levels are a consequence of human activity.

18/24

10. Hydrogen gas (H₂) is a promising alternative fuel because it does not produce greenhouse gases. How many molecules are present in 1.0 kg of hydrogen gas?

- A. 3.0×10^{23}
- B. 6.0×10^{23}
- C. 3.0×10^{26}**
- D. 6.0×10^{26}

2/24!!

11. What is the effect of infrared energy on matter?

- A. It excites bonding electrons.
- B. It increases molecular rotation.
- C. It breaks chemical bonds.
- D. It increases the vibration of chemical bonds.**

19/24

12. Which conclusion was considered "very likely" in the 2001 report of the Intergovernmental Panel on Climate Change?

- A. The 1990's were the warmest decade of the century.**
- B. The observed warming of the past 100 years is due solely to climate variability.
- C. The Arctic sea ice thickness decreased approximately 40% during late summer/early fall.
- D. Temperatures in the Northern Hemisphere during the past century are the warmest of any century in the past millennium.

9/24!

13. Both the Clinton and Bush (the younger) administrations have been unwilling to sign the Kyoto Protocol. What has been their primary objection to the treaty?

A. The target emission levels are not sufficiently low to affect the greenhouse effect.

B. The treaty does not include a provision for trading emission allowances.

C. Developing countries are not required to control greenhouse gas emissions. 22/24

D. Enforcement of the treaty will be impossible.

14. Identify the single most effective strategy to reduce carbon dioxide emissions.

A. Use methane rather than gasoline for fuel in cars and trucks.

B. Develop alternate energy sources that do not rely on fossil fuels. 22/24

C. Use wood as a home heating fuel.

D. Convert all vehicles to diesel fuel.

15. Where is most of the carbon on earth found?

A. in the form of fossil fuels

B. in the forests

C. in deep oceans 9/24!

D. in the atmosphere

16. Which substances are regulated by the Kyoto Protocol?

I. argon

II. carbon dioxide

III. nitrogen

IV. nitrous oxide

V. sulfur hexafluoride

A. I, II and III only

B. I and III only

C. II and V only

D. II, IV and V only 21/24

17. *In the United States today, which two energy sources contribute almost equally to our total energy usage?*

A. coal and natural gas 18/24

B. petroleum and natural gas

C. petroleum and nuclear electric power

D. coal and nuclear electric power

18. *The conclusion that it is impossible to **completely** convert heat into work without making other changes in the universe is*

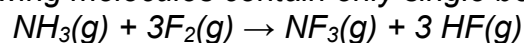
A. based on erroneous observations.

B. the concept that increasing entropy characterizes all changes in the universe.

C. another way of stating that all energy is either thermal energy or heat.

D. the second law of thermodynamics. 18/24

19. The following molecules contain only single bonds.



Based upon the data in the Table of Bond Energies, the heat evolved or absorbed per mole of NH_3 that reacts is

A. +51 kJ/mol.

B. +867 kJ/mol.

C. -51 kJ/mol.

D. -867 kJ/mol.

12/24

20. The heat of combustion of ethane, C_2H_6 , is 1560 kJ/mol. What is the heat of combustion of ethane, in kJ per gram?

A. 195 kJ/g

B. 51.9 kJ/g

C. 9.39×10^{26} kJ/g

D. 2.59×10^{-21} kJ/g

13/24

21. The energy that flows from a warmer body to a colder body is called

A. heat.

22/24

B. temperature.

C. potential.

D. work.

22. Thermal energy

A. decreases as the temperature of a body increases.

B. is characterized by the random motion of molecules. **21/24**

C. is the only form of energy that can be transformed into work with 100% efficiency.

D. causes the mass of a body to increase.

23. In an exothermic chemical reaction

A. the mass of the products is greater than the mass of the reactants.

B. the mass of the products is less than the mass of the reactants.

C. heat is released as the reaction proceeds. **23/24**

D. heat is absorbed as the reaction proceeds.

24. The combustion process for an effective fossil fuel must have an activation energy that is neither too high nor too low. Why is it problematic if the combustion has a very low activation energy?

A. The fuel will evaporate too easily and be hard to transport and store.

B. The fuel will ignite too easily and be hazardous. **8/24!!**

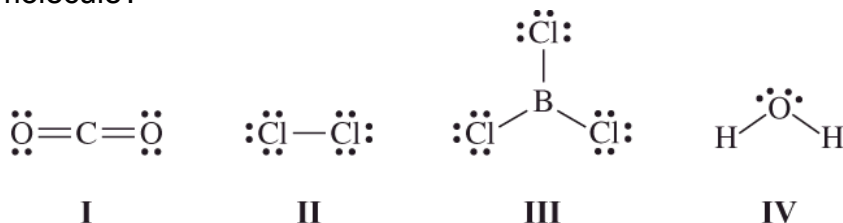
C. Upon combustion, fuels with low activation energies produce greenhouse gases.

D. Upon combustion, fuels with low activation energies will not release useful amounts of energy.

25. The first law of thermodynamics states that
- A. energy is the capacity to do work.
 - B. doing work is defined as causing movement against a resisting force.
 - C. heat flows from a warmer body to a cooler body.
 - D. energy is neither created nor destroyed. 18/24**
26. In which example is the entropy of the initial state **greater than** the entropy of the final state?
- A. A building collapses during an earthquake.
 - B. A lump of sugar dissolves in a cup of warm water.
 - C. Liquid water freezes into ice. 16/24**
 - D. Liquid water evaporates.
27. The total energy consumption of North America is matched today by
- A. South and Central America.
 - B. Europe.
 - C. the Middle East and Africa.
 - D. the Pacific Asian countries. 16/24**
28. Although the use of petroleum, natural gas and coal as fuels share many risks, a major risk associated more with coal than with the two other fuels is the
- A. production of greenhouse gases upon burning it.
 - B. potential harm to the environment as it is recovered and transported.
 - C. significant danger to workers who labor to recover it from the earth. 20/24**
 - D. eventual depletion of this resource.
29. *In the petroleum industry, what does a refinery do?*
- A. It separates crude oil into fractions consisting of compounds with similar properties. 23/24**
 - B. *It separates crude oil from the coal with which it is almost always found.*
 - C. *It mixes natural gas or coal with crude oil in order to remove the impurities from the crude oil.*
 - D. *It produces the machinery by which crude oil is removed from the ground.*
30. *Which is produced in the greatest amount from a barrel of petroleum?*
- A. *asphalt and road oil*
 - B. gasoline 21/24**
 - C. *home heating oil*
 - D. *lubricants and waxes*
31. *Cracking is*
- A. the breaking of larger molecules into smaller ones. 21/24**
 - B. *the combination of fuel with oxygen.*
 - C. *any reaction that is accompanied by the release of heat.*
 - D. *the heating of a solution and condensation of its vapors.*

32. A gasoline's octane rating is
- A. a measure of the gasoline's resistance to causing knocking in a vehicle's engine. 9/24!!**
 - B. a measure of the pollutants produced by burning the gasoline in a vehicle's engine.
 - C. a measure of the energy content of the gasoline; the higher the rating, the better the gas mileage.
 - D. a measure of the purity of the gasoline; the higher the rating the smaller the number of components in the mixture.
33. Alternative energy sources are currently being researched in effort to replace our dependence on fossil fuels. Which is *not* a current research effort in this regard?
- A. Obtaining alternative fuels from renewable sources such as garbage.
 - B. Reintroducing the use of tetraethyl lead to increase the octane rating of gasoline. 19/24**
 - C. Converting coal into gaseous and liquid fuels similar to petroleum products.
 - D. Increasing the use of farm product biomass, such as corn, to produce ethanol.
34. A 4-L sample of water contains 80 μg of lead. What is this lead concentration, in ppb?
- A. 20 12/24!**
 - B. 80
 - C. 320
 - D. 500
35. What is the molarity of sodium chloride in a solution containing 0.50 mol of sodium chloride in 500 mL of water?
- A. 0.25 M
 - B. 0.50 M
 - C. 1.0 M 17/24**
 - D. 5.0 M
36. Which is the best definition of specific heat?
- A. The quantity of heat energy that must be absorbed to make one gram of a substance boil.
 - B. The quantity of heat energy that must be absorbed to increase the temperature of one gram of a substance by one degree Celsius. 18/24**
 - C. The boiling point of a substance.
 - D. The difference between the freezing point and the boiling point of a substance.
37. Which covalent bond is the most polar?
- A. H-H
 - B. H-O 16/24**
 - C. H-N
 - D. H-S

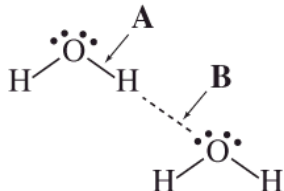
38. Which of the molecules drawn below contains polar covalent bonds but is **not** a polar molecule?



- A. I only
 B. III only
 C. II and IV only

D. I and III only **5/24!!**
 (Note: partial credit was given for A)

39. The drawing shows two water molecules. Which statement is correct?



- A. **A**: covalent bond; **B**: hydrogen bond; **B** is stronger
 B. **A**: hydrogen bond; **B**: covalent bond; **A** is stronger
C. A: covalent bond; B: hydrogen bond; A is stronger **19/24**
 D. **A**: hydrogen bond; **B**: covalent bond; **B** is stronger

40. Which is **not** a consequence of hydrogen bonding between water molecules?

- A. Water has a high boiling point.
 B. Ice floats on water.
 C. Water has a high specific heat.
D. Water is colorless and odorless. **18/24**

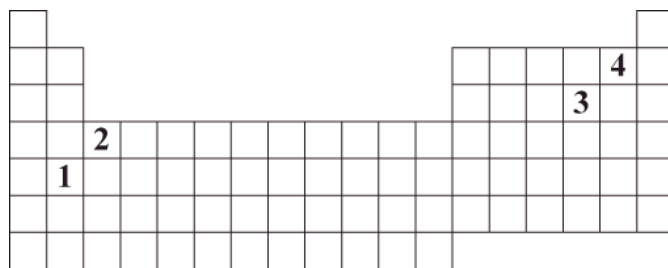
41. When a solution of ethanol, C_2H_5OH , is formed in water, the ethanol molecules

- A. are attracted to the nonpolar water molecules.
B. form hydrogen bonds to the polar water molecules. **12/24!**
 C. form covalent bonds to the polar water molecules.
 D. are not attracted to the polar water molecules.

42. The attractions between anions and cations in a crystal are known as

- A. covalent bonds.
 B. polar covalent bonds.
 C. hydrogen bonds.
D. ionic bonds. **22/24**

43. Numbers 1–4 are used to identify four different elements. Based on the organization within the periodic table, which element is expected to have 2+ charge when it forms an ion?



- A. 1
 B. 2
 C. 3
 D. 4

12/24!

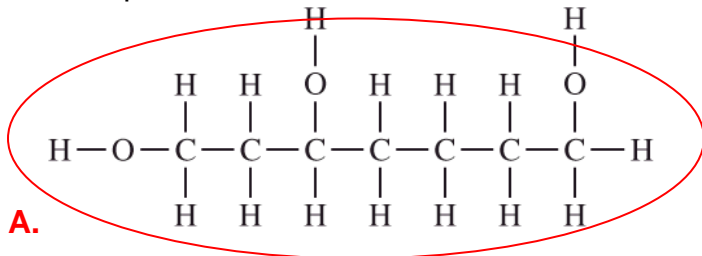
44. What is the formula of the ionic compound formed between magnesium, Mg, and chlorine, Cl?

- A. MgCl
 B. Mg₂Cl₂
 C. Mg₂Cl

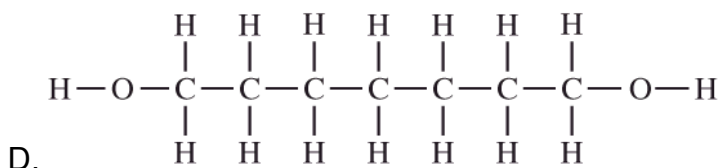
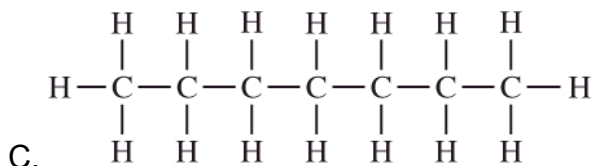
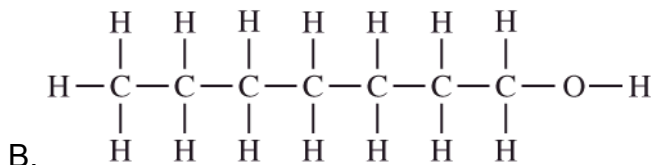
D. MgCl₂

12/24!

45. Which compound should be the most soluble in water?

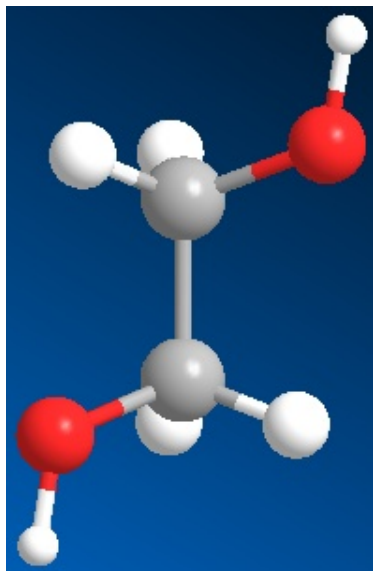


17/24



Bonus Problems (5 points each)

1) Consider the molecule ethylene glycol, $C_2H_6O_2$, shown below. While carbon dioxide has only 4 vibrational modes, ethylene glycol has many more. Two of these different vibrations are described below. For each vibration, state whether or not it will absorb infrared radiation, and why, and determine which of the two vibrations should absorb IR more strongly. Note that each carbon (gray) has a tetrahedral geometry, bonded to the other carbon, two hydrogen atoms (white), and an OH group (red oxygen, white hydrogen).



a) A vibration which stretches the C-C bond in the center of the molecule and simultaneously compresses the 2 C-O bonds.

This vibration moves the centers of negative charge (the Os) relative to the centers of positive charge (H and C), and thus changes the charge distribution. This will absorb IR radiation strongly. +2

b) A vibration which symmetrically stretches all 4 of the C-H bonds on the two carbons.

This vibration leaves the centers of negative charge in place, while producing a symmetric expansion in some of the positive charge. This will not absorb IR strongly, if at all. +2

Which absorbs IR more strongly (circle one)?

Vibration a
+1

Vibration b

2) Ethylene glycol is used as an antifreeze agent in windshield wiper fluid. However, like ethanol, it can be burned as a fuel, alone or as an additive in gasoline.

a) Does the combustion of ethylene glycol produce more or less CO_2 per mole than the combustion of ethanol?

b) Does that same combustion require more or less O_2 per mole than does ethanol?

c) Do you expect the combustion of ethylene glycol to be exothermic or endothermic?



Any attempt at a balanced equation was worth 1 point. A correctly balanced pair was another +1. Note that the chemical formula for ethanol, if you didn't know it, was provided for you in question #41.

Recognizing that glycol produces the same amount of CO_2 as ethanol (they have the same number of carbons) +1

Recognizing that glycol requires less O_2 than ethanol +1

Remembering that all combustion reactions are exothermic +1

3) Discuss the solubility of ethylene glycol in water.

a) Do you expect it to be insoluble, slightly soluble or very soluble in water?

b) How does its solubility compare to that of ethanol, C_2H_5OH ?

c) Draw the structure of the ethylene glycol dissolved in water, and discuss the role of intermolecular forces.

Ethylene glycol has TWO OH groups, each of which is capable of hydrogen bonding. Thus, it is likely to be very soluble in water. Using this knowledge OR the fact that glycol must dissolve in water to be of use as an antifreeze agent was worth one point.

Recognizing that ethanol only has one OH group capable of hydrogen bonding, and thus is likely less soluble than glycol +1

Drawing any attempt at the solvated molecule was worth 1 point – if you managed to draw glycol itself correctly, which should be possible given that it appears on the previous page of the exam

Correctly adding SOME of the hydrogen bonds was worth 1 point

Arriving at a final structure that looks something like the one below was worth the final point. Note that many more hydrogen bonds are possible between the OH groups of glycol and the water molecules, BUT no hydrogen bonds are possible between waters and the H atoms attached to C atoms through NONpolar covalent bonds.

