Chemistry 500

Spring 2000

Dr. Hunter

Old Exams for Spring 1997
Chemistry 500, First Quiz

Spring 1997

Dr. Hunter

Your Name: _______________  _______________
last       first

Student Number: _______________

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. *Circle the letters of the parts you want me to mark.* When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade:  /50 (i.e. 10% of the final grade)
1. (20 marks in total) For four out of five of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. The three states of matter are solids, liquids, and gasses. Briefly describe how you can tell them apart.

b. Which are the two major gasses that are present in air (give the name and formula of each)? Which is the most reactive?

c. Compared to the gray metal cabinet at the front of the lecture hall, describe objects found in a kitchen that have a volume equal to about 1 ppm and 1 ppb. Define 1 ppt.

d. Circle each of the following reactions that are balanced.
   
   \[
   \begin{align*}
   &i) \quad \text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_3 \\
   &ii) \quad \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \\
   &iii) \quad \text{C}_6\text{H}_6 + 7\text{O}_2 \rightarrow 6\text{CO}_2 + 3\text{H}_2\text{O} \\
   &iv) \quad \text{C}_6\text{H}_12 + 9\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \\
   &v) \quad \text{C}_2\text{H}_6 + 3\text{Cl}_2 \rightarrow \text{C}_2\text{H}_3\text{Cl}_3 + 3\text{HCl}
   \end{align*}
   \]

e. Balance each of the following reactions.

\[
\begin{align*}
   &\text{C}_2\text{H}_4 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \\
   &\text{NaClO}_4 \rightarrow \text{NaCl} + \text{O}_2 \\
   &\text{H}_2\text{SO}_4 + \text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{O}
\end{align*}
\]
2. (16 marks in total) For two out of three of the following questions, give an answer in the space provided. Show your reasoning, any assumptions you make, and/or your work.

a. Explain why air is thick near the ground and thin higher in the atmosphere.

b. From the information on the overhead (Table 1.2 in the text), which cities exceeded the EPA permissible limits for carbon monoxide? By how much did New York city exceed the EPA permissible limit for ozone.

c. Explain the cause of carbon monoxide’s toxicity.
3. (14 marks in total) For the following question, give an explanation in the space provided. Clearly explain your reasoning.

a. Describe the steps one would use to determine the structure of a new molecule.
Chemistry 500, Second Quiz

Spring 1997

Dr. Hunter

Your Name: ___________________________ last first

Student Number: ______________________

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade: /50 (i.e. 10% of the final grade)
1. (20 marks in total) For *four out of five* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. What is meant by the term Allotrope? Give an example.

b. Explain what someone means when they call ozone molecular sunscreen.

c. What is meant by the term Free Radical? Give an example.

d. Give five uses of halocarbons such as CCl₂F₂ and CCl₃Br.

e. If your car went 203 miles and used 13 gallons of gas, what would its milage be in miles per gallon. Comment on the significant figures of your answer.
2. (20 marks in total) For four out of five of the following molecules give the Lewis electron structures in the space provided. Show your reasoning, any assumptions you make, and/or your work.

H

H C F

H

N N

H H

C C

H H

O O

H O H
3. (10 marks in total) Using words and pictures, describe the structure of an atom.
Chemistry 500, Third Quiz

Spring 1997

Dr. Hunter

Your Name: _______________, _______________  Student Number: _______________

last first

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade:  /50 (i.e. 10% of the final grade)
I. (20 marks in total) For *four out of five* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. What is meant by the term Clatherates and where are they found.

b. Give five major sources for the methane in the atmosphere.

c. A mole contains how many atoms? If each of these was the size of a regular marshmallow, describe how big the bag would have to be that would be needed to hold all of them.

d. Describe what Olestra is made out of.

e. Name five greenhouse gasses.
2. (15 marks in total) For each of the following molecules, use the Lewis structure to predict the bond angles and relative bond lengths.

\[
\begin{array}{c}
\text{H} & \text{H} \\
\text{C≡N} & \text{C}=\text{C} & \text{C} & \text{C} & \text{H} \\
\text{H} & \text{H} \\
\end{array}
\]

\[
\begin{array}{c}
\text{H} \\
\text{N} & \text{C} & \text{C} & \text{C} & \text{H} \\
\text{H} & \text{H} \\
\end{array}
\]

\[
\begin{array}{c}
\text{H} \\
\text{C} & \text{C} & \text{C} & \text{N} & \text{C} & \text{H} \\
\end{array}
\]
3. (15 marks in total) For three out of four of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. For the molecule \( \text{C}_6\text{H}_6\text{O} \), calculate both the molecular weight of an individual molecule and the weight of a mole of molecules.

b. For the molecule \( \text{NH}_3 \), calculate the percent composition for both the nitrogen and the hydrogen.

c. Giving your reasoning, predict whether \( \text{C}_2\text{H}_5\text{Cl} \) or \( \text{CO}_2 \) would be a stronger greenhouse gas.

d. Describe the basic chemical structure of Olestra as clearly as you can.
Chemistry 500, Forth Quiz

Spring 1997

Dr. Hunter

Your Name: ___________________________    Student Number: ________________
               last               first

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may *not* program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a *choice* of which parts to answer. *Circle the letters of the parts you want me to mark.* When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade:    /50 (i.e. 10% of the final grade)
1. (20 marks in total) For four out of five of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. In molecular terms, what causes heat?

b. Give a definition of the 1\textsuperscript{st} law of thermodynamics.

c. Explain why people changed from using wood to using coal and oil as their main forms of energy at the end of the last century.

d. What is the definition of a calorie?

e. Explain what is meant by activation energy.
2. (15 marks in total) Using text and a diagram, explain in detail what happens when something burns.

Bonus Question (up to four extra points, use the symbols for the elements as your answers).

1. What ships with holes in them do..................

2. A crazy inmate........................................
3. (15 marks in total) For *three out of four* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. Explain what happens to peat when it is buried at high temperature and pressure.

b. Explain the distillation process used to refine oil.

c. What are the main problems involved with using hydrogen as fuel?

d. What are the two ways that solar energy can be converted into electricity?
Chemistry 500, Final Exam

Spring 1997

Dr. Hunter

Your Name: _______________  last  _______________  first

Student Number: _______________  

For all of the questions on the following six pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. Give clear explanations/reasoning for each of your answers. Use diagrams in your answers where appropriate. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This exam is scheduled for 2 hours.

Total Grade:   /100 (i.e. 40% of the final grade)
1. (20 marks in total) For *four out of five* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. Define the term catalyst.

b. Would you expect a Nylon fiber or a similar Polyester fiber to be stronger? Give your reasoning.

c. Is Kevlar a commodity plastic? Why or why not? Give two uses for it.

d. For the molecule $\text{CH}_3\text{F}$, calculate the percent composition for all of the elements.

e. Showing your work, estimate the volume of air you breathe each day.
2. (15 marks in total) Clearly explain three strategies for making a plastic object less flammable.
3. (15 marks in total) For *three out of four* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. Balance each of the following reactions.

\[ \text{NaClO}_4 \rightarrow \text{NaCl} + \text{O}_2 \]

\[ \text{C}_2\text{H}_2 + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

\[ \text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{HCl} \]

b. For each of the following reactions, state whether they are balanced and then whether an increase in the amount of CO\textsubscript{2} gas would speed up or slow down the reaction.

\[ \text{C}_8\text{H}_{18} + 12\text{O}_2 \rightarrow 8\text{CO}_2 + 8\text{H}_2\text{O} \]

\[ \text{Li}_2\text{O} + \text{CO}_2 \rightarrow \text{Li}_2\text{CO}_3 \]

c. Define an exothermic reaction and then give one example of one that we talked about in class.

d. Name the following polymer and describe two large volume uses for it found in consumer products.

[Chemical structure diagram of a polymer]
4. (20 marks in total) For four out of five of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. Explain why air is thick near the ground and thin higher in the atmosphere.

b. What is the difference between chronic and acute toxicity. Give one example of a chemical showing each kind of toxicity.

c. Define the term isotope and give two examples.

d. Discuss the x-ray crystallography (x-ray diffraction) experiment and what information you get from it.

e. How does a green house gas keep the earth warm?
5. (15 marks in total) For the following molecules, give the Lewis electron structures in the space provided. Show your reasoning, any assumptions you make, and/or your work. Predict the bond angles around each atom.
6. (15 marks in total) For *three out of four* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. What is meant by the term Clatherates and where are they found.

b. For the molecule \( \text{C}_2\text{H}_7\text{N} \), calculate both the molecular weight of an individual molecule and the weight of a mole of molecules.

c. Why have the measured concentrations of lead in the environment dropped so much in recent years.

d. Give two examples of halocarbons and describe how they effect the ozone hole.
Chemistry 500, First Quiz

Spring 1997
Dr. Hunter

Your Name: ___________________________ last first

Answers

Student Number: ______________________

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. *Circle the letters of the parts you want me to mark.* When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade: /50 (i.e. 10% of the final grade)
1. (20 marks in total) For four out of five of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. The three states of matter are solids, liquids, and gasses. Briefly describe how you can tell them apart.
   - Solids & liquids are dense, gasses aren't.
   - Solids are rigid.
   - Liquids flow down hill, can be kept in a box.
   - Gasses can flow upwards, will flow out of box.

b. Which are the two major gasses that are present in air (give the name and formula of each)? Which is the most reactive?
   - Oxygen, O₂, is more reactive.
   - Nitrogen, N₂.

c. Compared to the gray metal cabinet at the front of the lecture hall, describe objects found in a kitchen that have a volume equal to about 1 ppm and 1 ppb. Define 1 ppt.
   - 1 ppm ≈ 1 sugar cube, small grape, large peanut.
   - 1 ppb ≈ 1 sugar grain, salt grain, etc.
   - 1 ppt = 1 part per trillion, 1/1,000,000,000,000.

d. Circle each of the following reactions that are balanced.
   - \( \text{(i)} \ 2\text{NO}_2 + H_2O \rightarrow HNO_3 \)
   - \( \text{(ii)} \ 2\text{SO}_3 + H_2O \rightarrow H_2\text{SO}_4 \)
   - \( \text{(iii)} \ 6\text{C}_6\text{H}_6 + 7\text{O}_2 \rightarrow 6\text{CO}_2 + 3\text{H}_2\text{O} \)
   - \( \text{(iv)} \ 4\text{C}_2\text{H}_2 + 9\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} \)
   - \( \text{(v)} \ 2\text{C}_2\text{H}_6 + 3\text{Cl}_2 \rightarrow 2\text{C}_2\text{H}_3\text{Cl}_3 + 3\text{HCl} \)

2 points for each to a 5 point maximum.

e. Balance each of the following reactions.
   - \( \text{C}_2\text{H}_4 + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 2\text{H}_2\text{O} \)
   - \( \text{NaClO}_4 \rightarrow \text{NaCl} + \text{O}_2 \)
   - \( \text{H}_2\text{SO}_4 + 2\text{NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \)
2. (16 marks in total) For two out of three of the following questions, give an answer in the space provided. Show your reasoning, any assumptions you make, and/or your work.

a. Explain why air is thick near the ground and thin higher in the atmosphere.

Gravity attracts the air molecules close to the ground. On its own, it would cause the air to form a thick layer near the ground only with nothing higher. The speed of the air molecules makes them fly up into the air. On its own, it would cause the air to be the same thickness at all altitudes.

The balance of gravity and the speed of the molecules gives the observed distribution, which is thicker near the ground & thinner as you go up.

b. From the information on the overhead (Table 1.2 in the text), which cities exceeded the EPA permissible limits for carbon monoxide? By how much did New York city exceed the EPA permissible limit for ozone.

The EPA limit for carbon monoxide is 9 ppm. New York & Los Angeles both exceeded this limit.

Ozone:
New York level 0.18 ppm
EPA Limit 0.17 ppm

\[
\frac{0.18 \text{ ppm}}{0.17 \text{ ppm}} \times 100 = 105.88\% \text{ of limit}
\]

\[
150\% - 100\% = 50\%
\]

c. Explain the cause of carbon monoxide's toxicity.

Carbon monoxide binds very tightly to the iron atom in Hemoglobin. This is the molecule that carries oxygen to the body from the heart/lungs. It does this by the O₂ attaching in the same spot as the CO. Once the CO binds, O₂ can't, so the body dies of lack of oxygen because the Hemoglobin isn't carrying any Fe⁺₂⁺ the toxic lab work.
3. (14 marks in total) For the following question, give an explanation in the space provided. Clearly explain your reasoning.

a. Describe the steps one would use to determine the structure of a new molecule.

A) Elemental Analysis
- Qualitative
  - determines which elements are there
- Quantitative
  - determines the relative amounts of the different elements

⇒ Molecular Formula

B) X-Ray Diffraction
- uses single crystals
  - x-rays → bent x-ray
  - crosses → bent x-ray
  - angles and brightnesses of bent (diffraction)

⇒ a picture of the molecules

C) Spectroscopic Methods
- especially Nuclear Magnetic Resonance
  - (like MRI in hospital)
  - gives indirect picture of molecules

D) Total costs in thousands ¥
  - Takes a few days or weeks ¥ Typical
Chemistry 500, Second Quiz

Spring 1997

Dr. Hunter

Your Name: ___________ Answers last first Student Number: ___________

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade: _______/50 (i.e. 10% of the final grade)
1. (20 marks in total) For *four out of five* of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. What is meant by the term *Allotrope*? Give an example.

Two or more forms of the same element that differ only in the arrangements of the atoms. 

* eg. diamond and graphite for carbon

* O₂ and O₃ for oxygen

b. Explain what someone means when they call ozone molecular sunscreen.

Ozone strongly absorbs ultraviolet light in the upper atmosphere and therefore prevents it from reaching the surface just like sunscreen protects our skin.

c. What is meant by the term *Free Radical*? Give an example.

* A molecule with an odd number of electrons

* eg. 

\[ \text{H} + \cdot \text{O} \]

\[ \cdot \text{O} = \cdot \text{O}^+ \]

\[ \text{H} \cdot \text{O} \]

\[ \text{H}_2 \text{O} \]

\[ \text{H}_2 \text{O}_2 \]

\[ \text{H}_2 \text{O}_2 \]

d. Give five uses of halocarbons such as CCl₂F₂ and CCl₃Br.

- Refrigerants in cars
- Aerosol propellents in spray cans
- Fire extinquishers
- Solvents in computer factories
- Dry cleaning agents
- Making styrofoam

etc.

e. If your car went 203 miles and used 13 gallons of gas, what would its milage be in miles per gallon. Comment on the significant figures of your answer.

\[
\begin{align*}
15.61 & \cdots \\
13 & \div 203 \\
13 & \div 13 \\
73 & \div 65 \\
80 & \div 80 \\
78 & \div 20 \\
\end{align*}
\]

about 16 miles/gallon

* We only have 2 significant figures for the number of gas so we can only have 2 significant figures in the answer.
2. (20 marks in total) For four out of five of the following molecules give the Lewis electron structures in the space provided. Show your reasoning, any assumptions you make, and/or your work.

\[ 1 + 1 + 1 + 4 + 7 = 14 \]

\[ 5 + 5 = 10 \]

\[ 1 + 1 + 1 + 4 + 4 = 12 \]

\[ 6 + 6 = 12 \]

\[ 1 + 1 + 6 = 8 \]
3. (10 marks in total) Using words and pictures, describe the structure of an atom.

- Atom has a relative large region composed the cloud of electrons around the nucleus.
- The nucleus is small and contains an approximately equal number of protons and neutrons.

- Positive charge
  
  \[ \text{p} = \text{proton} \]
  \[ r = \text{nue} \text{tr} \text{on} \]

- Light electron
  \[ e^{-} \]

- Expanded nucleus
  \[ p^+ p^+ n^- n^- p^+ p^+ n^- n^- \]

- Electrons can be one valence

The number of electrons = the number of protons for a neutral atom.
Chemistry 500, Third Quiz  

Spring 1997  

Dr. Hunter  

Your Name: _____________________________  
last  
first  

Student Number: ________________________  

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.  

Total Grade: _______/50 (i.e. 10% of the final grade)
1. (20 marks in total) For four out of five of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. What is meant by the term Clathrates and where are they found.

   Clathrates are compounds formed when small molecules such as methane get locked in holes in water ice. They are found under the surface in the arctic/antarctic and on the continental shelf.

b. Give five major sources for the methane in the atmosphere.

   - swamps
   - rice paddies
   - natural gas leaks
   - cattle/sheep
   - termites

c. A mole contains how many atoms? If each of these was the size of a regular marshmallow, describe how big the bag would have to be that would be needed to hold all of them.

   \[ 6.02\times10^{23} = 602000000000000000000 \]

   As big as the US and 650 miles high

d. Describe what Olestra is made out of.

   sugar and vegetable oil

e. Name five greenhouse gasses.

   \[ \text{CO}_2 \]
   \[ \text{CFCS} \]
   \[ \text{methane} \]
   \[ \text{CH}_3 \text{Br} \]
   \[ \text{H}_2\text{O} \]
   \[ \text{CFCs} \]
2. (15 marks in total) For each of the following molecules, use the Lewis structure to predict the bond angles and relative bond lengths.

\[ \text{s = short} \]
\[ \text{m = medium} \]
\[ \text{l = long} \]
3. (15 marks in total) For three out of four of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. For the molecule \( \text{C}_6\text{H}_6\text{O} \), calculate both the molecular weight of an individual molecule and the weight of a mole of molecules.

\[
6 \times 12 + (6 \times 1) + 16 = 94 \text{ amu per molecule}
\]

\[
94 \text{ g per mole}
\]

b. For the molecule \( \text{NH}_3 \), calculate the percent composition for both the nitrogen and the hydrogen.

\[
14 + 3 = 17 \quad \text{molecular weight}
\]

\[
\% \text{ N} = \frac{14}{17} \times 100 = 82 \%
\]

\[
\% \text{ H} = \frac{3}{17} \times 100 = 18 \%
\]

c. Giving your reasoning, predict whether \( \text{C}_2\text{H}_3\text{Cl} \) or \( \text{CO}_2 \) would be a stronger greenhouse gas.

\( \text{C}_2\text{H}_3\text{Cl} \) has a more complex structure; it would be expected therefore to have more vibrations and so would be expected to be a stronger IR absorber and hence a better greenhouse gas.

d. Describe the basic chemical structure of Olestra as clearly as you can.

It is composed of 6 to 8 fatty acids attached to sucrose oxygen atoms (in place of oh groups) via ester linkages.
Chemistry 500, Forth Quiz

Spring 1997

Dr. Hunter

Answers

Your Name: ___________________________  Student Number: ________________
l       f

For all of the questions on the following three pages, make sure you clearly explain your reasoning and show your work. You may use a calculator (you may not program information into your calculator) but may not use any other outside materials such as books or notes. If you are unsure of how to interpret any of the questions, please ask me for help. On some of the following questions, you have a choice of which parts to answer. Circle the letters of the parts you want me to mark. When you are done, please hand your exam in to me at the front and then either wait quietly in your desk or in the hallway. This quiz is scheduled for 30 minutes at which time class will resume.

Total Grade: /50 (i.e. 10% of the final grade)
1. (20 marks in total) For **four out of five** of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

   a. In molecular terms, what causes heat?

   Heat is due to the motion of molecule rotations, vibrations, and translations. The greater the amount of motion, the higher the heat content of the molecule.

   b. Give a definition of the 1st law of thermodynamics.

   The 1st law: Conservation of Energy. Energy is neither created nor destroyed, its form just changes. This holds only for the universe as a whole.

   c. Explain why people changed from using wood to using coal and oil as their main forms of energy at the end of the last century.

   The decreased availability of wood due to deforestation and increased population. Coal and oil also have much higher energy contents per ton.

   d. What is the definition of a calorie?

   The heat required to raise the temperature of one gram of water 1°C.

   e. Explain what is meant by activation energy.

   The energy required to initiate a reaction.

   ![Diagram of Activation Energy with starting materials and activation energy labels.](image-url)
2. (15 marks in total) Using text and a diagram, explain in detail what happens when something burns.

Heat from an initiator (e.g., a match) on the combustion zone volatilizes (evaporates) the solid or liquid fuel. For high molecular weight fuels, partial decomposition (pyrolysis) may also occur in the solid or liquid.

The fuel molecules in the gas phase are then further decomposed to small fuel molecules (e.g., CO, H₂, CH₄, C₂H₅, etc.) in the pyrolysis zone.

From here, they diffuse into the combustion zone (flame) where they react with oxygen from the air to produce CO₂, H₂O, etc. The exothermic process occurs via free-radical processes and gives off the heat that sustains the pyrolysis and volatilization of the fuel.

Bonus Question (up to four extra points, use the symbols for the elements as your answers).
1. What ships with holes in them do.......... Zn
2. A crazy inmate................................ 5i
3. (15 marks in total) For three out of four of the following questions, give a short answer in the space provided. Show your reasoning and/or your work.

a. Explain what happens to peat when it is buried at high temperature and pressure.

   The combination of heat and pressure causes it to lose small molecules like CO and H₂O (i.e., slow pyrolysis) and to slowly convert to illite-brown coal, bituminous coal, and then anthracite coal (which is almost pure carbon), successively.

b. Explain the distillation process used to refine oil.

   Crude oil is heated in the absence of air to several hundred degrees. The vapours are distilled in tall towers with the lower boiling (low molecular weight) fractions coming off of the top and heavier ones coming off at progressively lower heights.

   ![Distillation tower diagram]

   Oil distillation diagram

   - [Diagram of distillation process]
   - [Labelled diagram of distillation process]
   - [Distillation process diagram]
   - [Diagram of distillation process]

   - [Diagram of distillation process]
   - [Distillation process diagram]
   - [Diagram of distillation process]
   - [Distillation process diagram]

   c. What are the main problems involved with using hydrogen as fuel?

   - Cost
   - Explosive hazard
   - Low energy density per liter
   - Reacts with common metal alloys
   - Must be stored (if a liquid) at high pressure or low temperature

   d. What are the two ways that solar energy can be converted into electricity?

   - Photovoltaics: Solar Cells
   - Concentrated Solar Thermal Power: Sunlight heats a liquid to produce a high pressure gas to drive a turbine generator.