

Student Course Information

CHEM*1050 - General Chemistry II

Fall 2004

INSTRUCTOR: Dr. Lori Jones
OFFICE: MACN 331
PHONE: 824-4120 ext. 56123
E-MAIL: lojones@uoguelph.ca

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0. INTRODUCTION

This course outline describes CHEM*1050 in detail and identifies what is to be learned, and the administrative details of the course. It also provides you with a detailed schedule of events. Please read it carefully – it should answer the majority of your questions about the administration of CHEM*1050.

In this course, we will

- I. Study thermodynamics by considering enthalpy, entropy, free energy and the relationship of free energy to equilibrium.
- II. Determine oxidation states and examine oxidation-reduction reaction and electrochemistry.
- III. Consider the rates and mechanisms of chemical reactions.

It will be assumed that you understand the concepts covered in CHEM*1040, or an equivalent course, based on the pre-requisites of this course.

1. REQUIRED MATERIALS

- (a) **Textbook:** Chemistry, 3rd edition, John Olmsted III & Gregory M. Williams; The text along with a student solutions manual are shrink-wrapped together and may be purchased in the University Bookstore. (Note: This text and solutions manual were used in CHEM*1040 last year.)
- (b) **Electronic calculator** with \ln , \exp or e^x , \log_{10} and 10^x functions. Calculators or notebook computers capable of storing text information are **NOT** allowed in examinations.
- (c) **Laboratory Manual** for CHEM*1050. Purchased in the Department. Bring your laboratory manual to your first laboratory meeting.
- (d) **Safety goggles:** available in the University Bookstore. Safety goggles must be worn in the laboratory at all times.
- (e) **Lab coat** are required. These are available in the University Bookstore.

2. LECTURES

There are three lectures per week: Mondays, Wednesdays and Fridays from 12:30 – 13:20 in MacNaughton (MACN) 105.

3. LABORATORY

Labs begin in Week 1 on Monday, September 13 with mandatory safety training. The laboratory is an integral part of the course.

- (a) **Laboratory Time and Location**
You must take the labs in the time for which you have registered. If you do not attend your lab in Week 1 then you may lose your place.

If you have a scheduling problem you may be able to resolve it through WebAdvisor.

(b) **Laboratory Authorisation**

As proof that you belong in a specific lab section, bring a recent computer print-out of “My Class Schedule” from WebAdvisor to your first lab.

(c) **Quizzes**

A brief quiz will be held at the beginning of most laboratory sessions. Refer to the Laboratory Schedule for details (page 6). These quizzes count towards your laboratory grade, and will usually be based on the experiment that you are about to perform.

(d) **Laboratory Reports**

Laboratory reports are due exactly one week after the lab. Submit the report to your demonstrator at the beginning of the next laboratory period.

(e) **Laboratory Exemptions**

If you are repeating CHEM*1050, you may request an exemption from the lab. An application for a lab exemption must be made **before Tuesday, September 14** by filling in the application form posted on the bulletin board, around the corner from MACN 125.

A student who has earned **at least 60%** in the laboratory, but who fails the course as a whole, may be granted a lab exemption. The lab work must have been completed during one of the three preceding semesters in which the course was offered (CHEM*1050 is offered every semester).

Students repeating CHEM*1050 are strongly encouraged to attend the Problem Laboratories (see the lab schedule). You may attend any of the labs that week. The problem sheets may be picked up in any of the labs in the week preceding the Problem Laboratory.

4. **WEB SITE**

The web site can be accessed through the portal at <http://courselink.uoguelph.ca>. Your **username** is your Central Login Account ID (that part of your assigned University of Guelph e-mail address before the @ sign) and your **password** is your Central Login Account Password. The first page is “myWebCT: your name” which will list all your WebCT courses including CHEM*1050. **The CHEM*1050 web site is an integral part of the course and must be accessed daily.** If you have any technical problems using WebCT, move the cursor to the “Students” link at the top of the Courselink@Guelph page (Login page) and select the appropriate link from the menu. If you do not have a Central Login Account, visit the CCS help desk located in the library computer lab on the main floor. Go to <http://www.uoguelph.ca/ccs/accounts/index.html> for more information.

5. HELP

- (a) **Office hours:** Dr. Jones will be available for consultation and help for an hour after each class as well as by appointment.
- (b) **Supported Learning Groups (SLGs)**
SLGs are regularly scheduled small group study sessions. Attendance is voluntary and open to all students enrolled in the course. The study groups are facilitated by successful senior students who have recently taken the course. SLG leaders attend all lectures, take notes and work with faculty and staff to create study activities that integrate course content with effective approaches to learning. Students who attend SLG sessions have an opportunity to apply and demonstrate their understanding of course concepts in a safe practice environment. The group study format exposes students to various approaches to learning, problem-solving, and exam preparation. The session times and locations will be announced during the first week of classes. These sessions have proven very helpful for students.
- (c) The web site contains a variety of activities to help you with the course. The Discussion site gives students the opportunity to post questions about the course and others in the class, who may be on-line at the same time, can supply timely answers or suggestions. There are practice quizzes and examinations, an animation on electrochemical cells, many examples with full solutions, a question of the week, and much more.

Please note, all important announcements will be posted on the web site.

6. EXAMINATIONS AND GRADES

- (a) The course grade will be calculated as follows:
- | | |
|-------------------|-----|
| Midterm | 30% |
| Final Examination | 40% |
| Laboratory | 20% |
| Online Quizzes | 10% |

(b) **Quizzes**

The quizzes are delivered on the web site. You may use the text and any notes when attempting the quizzes. The maximum benefit from the quizzes will be obtained **if you do them on your own** and under examination conditions. The quizzes are 75 minutes in duration and will be available on the dates listed below from 1:00 a.m. Monday until 11:55 p.m. Thursday. Answers and help for questions on your quiz may be accessed on the Friday, Saturday and Sunday of the quiz week. Each quiz can **ONLY** be accessed at these times. **If a quiz is not attempted, a grade of zero will be assigned.** Please do not leave your quiz attempt until the last day!

Quiz #1 - Thermochemistry, Entropy and Spontaneity	Sept. 27 - Sept. 30
Quiz #2 - Redox and Electrochemical Cells	Nov. 01 - Nov. 04
Quiz #3 - Electrochemistry	Nov. 15 - Nov. 18
Quiz #4 - Kinetics	Nov. 29 - Dec. 02

- (c) **Midterm Exam Date: Saturday, October 16, 09:30 - 11:00 ROZH 104**
The midterm exam will consist of multiple choice questions, short answer questions, and problems similar to those in the problem assignments.

- (d) **Midterm Conflicts**
If you have a legitimate conflict you will be given the opportunity to write an alternate CHEM*1050 midterm exam on:

Thursday, October 14, 2004. 5:30 - 7:00 p.m.

You must give your instructor a note including your name, ID number, and reason for requesting the alternate midterm time. Deadline is Friday, October 8, 2004. The location will be announced prior to the date.

- (e) **Final Examination Date: Thursday, December 9, 8:30 - 10:30**
The final exam will cover the entire course and will consist of multiple choice questions, short answer questions, and problems. (**Note:** Room assignments will be made by the Registrar's office nearer to the final exam period).
- (f) All examinations will be closed book. No written or printed materials of any kind permitted. Electronic calculators can be used but no electrical outlets are available in exam rooms. Computers or calculators capable of storing text information or formulas are not allowed in examinations.

7. POLICY ON MISSED WORK

A grade of zero will be assigned for any missed quiz, lab report or examination except for valid medical or compassionate reasons. Medical or compassionate reasons that may excuse you from the missed work can be considered only if you follow the correct procedure for requesting such as exemption. For missed lab work, refer to the "purple page" handed out in the laboratory.

For a missed midterm, documentation must be given to your instructor in person. Do not request that program counselors or others mail the documentation to the Chemistry Department; we are not responsible for documentation lost because it was not sent to the right person. There is no need to consult a doctor to obtain a note. However, if you have consulted a medical practitioner because of illness or injury, the doctor's note is acceptable documentation.

In the case of a missed midterm, if a valid reason for missing the midterm is received, the grade on the missed midterm will be estimated from the student's performance on those questions on the final examination which are related to material covered by the missed examination. **No make-up midterm will be given.**

In the case of a missed final examination, you should contact your program counselor as soon as possible. Official documentation is required for a missed final examination, e.g. Doctor's note.

7. Lecture and Reading Schedule – FALL 2004

Please read the appropriate sections in the text before lectures.

Week	Date	Lecture	Material Covered in Lecture	Text Ref.	Problem Assignment
1	Sept. 13 to Sept. 17	1 2 3	Course Info., Thermodynamic def'ns Energy Changes Calorimetry	12.1 12.2 12.3	1
2	Sept. 20 to Sept. 24	4 5 6	Enthalpy, ΔH° Enthalpy & Intermolecular Forces Covalent Bond Energies	12.4 12.5 9.2	2
3	Sept. 27 to Oct. 01	7 8 9	Energetics of Ionic Compounds Spontaneity & Entropy Entropy	7.5 13.1-.2 13.3	3
4	Oct. 04 to Oct. 08	10 11 12	Spontaneity & Free Energy Thermodynamics and Equilibrium Bioenergetics	13.4 15.3 13.6	4
5	Oct. 11 to Oct. 15	- 13 14	Holiday (Thanksgiving) Review Class Review Class		5
	Oct. 16		Midterm Exam: 9:30 – 11:00 a.m.		
6	Oct. 18 to Oct. 22	15 16 17	Review Redox, Oxidation States Half Reactions, Balancing Redox More Redox	18.1 18.2	6
7	Oct. 25 to Oct. 29	18 19 20	Galvanic cells, Cell notation Cell potentials, Std Potentials Free Energy and Electrochemistry	18.3 18.4 18.5	7
8	Nov. 01 to Nov. 05	21 22 23	The Nernst equation Applications of Galvanic Cells Electrolytic Cells	18.5 18.6 18.7	8
9	Nov. 08 to Nov. 12	24 25 26	Electrolysis Applications Reaction Rate, Instantaneous Rate	18.7 14.2	9
10	Nov. 15 to Nov. 19	27 28 29	Rate Laws Models of Reaction Rates, Radioactive decay	14.3 14.4 21.7	10
11	Nov. 22 to Nov. 26	30 31 32	Elementary Reactions Reaction Mechanisms Rates and Temperature	14.1 14.5 14.6	11
12	Nov. 29 to Dec. 03	33 34 35	Chain Reactions, Catalysis Review class Review class	14.7	12
	Dec. 9		Final Exam: 8:30 – 10:30 a.m.		

Disclaimer: The precise sequence and timing of the above schedule is at the discretion of the Professor. The schedule above is the best zeroth-order approximation.

9. LABORATORY SCHEDULE – FALL 2004

Week 1 Sept. 13 – 17	Check-in Safety in the Laboratory (WHMIS)	No Quiz
Week 2 Sept. 20 – 24	Experiment 1 - Enthalpy of formation (Quiz on WHMIS and on Experiment 1)	Quiz
Week 3 Sept. 27 – Oct. 01	Experiment 2 - Measurement of an Equilibrium Constant	Quiz
Week 4 Oct. 04 – 08	Experiment 3 - Determination of ΔG° , ΔH° , ΔS°	Quiz
Week 5 Oct. 11* – 15	Problem Lab (Note: Those scheduled in one of the Monday labs, please attend one of the other problem labs running this week.)	No Quiz
Week 6 Oct. 18 – 22	Experiment 4 - Oxidation and Reduction (Part A)	No Quiz
Week 7 Oct. 25 – 29	Experiment 4 - Oxidation and Reduction (Part B)	Quiz
Week 8 Nov. 01 – 05	Experiment 5 - Galvanic Cells	Quiz
Week 9 Nov. 08 – 12	Experiment 6 – Electrolysis	Quiz
Week 10 Nov. 15 – 19	Experiment 7 - Chemical Kinetics	No Quiz
Week 11 Nov. 22 – 26	Clean-up	No Quiz
Week 12 Nov. 29 – Dec. 03	Check Final Lab Grades Problems Lab	No Quiz

* October 11 is Thanksgiving – No Classes are Scheduled.

10. WEEKLY PROBLEM ASSIGNMENTS

Problems are assigned to provide reinforcement of the principles covered in lectures, to allow you to develop problem solving techniques and to check your own knowledge before examinations. Work done on these problems is not graded, but mastering the problems provides you with an excellent way of finding out how well you really understand the chemistry presented in lectures. There is a good correlation between mastering the problems on a week-by-week basis and performance on examinations.

Work the problems in the week that the material is covered in lectures. A common reason why students fail first year Chemistry is that they fall so far behind with the material that they never catch up. Lectures become harder to comprehend without the reinforcement effect of constant practice.

Work the problems independently. Working from the solutions is **not** useful for learning. If you have difficulties, seek help as soon as possible.

Solutions to problems

The detailed solutions to the problems from the text are contained in the "Student Solutions Manual" which is included with the text. Answers and solutions to the problems below which are not from the text will be posted on the website. If you are having difficulty with the material, please see your professor.

PROBLEMS

ASSIGNMENT 1:

- 1-1: Text: 12.1, 12.3, 12.7, 12.11, 12.15, 12.19, 12.21, 12.23, 12.49, 12.51, 12.57, 12.69, 12.71, 12.79, 12.83.
- 1-2: Calculate the work needed to make room for products in the combustion of 1 mole of methane gas to carbon dioxide and water vapour at STP.
- 1-3: If a piston expands into a vacuum, against zero pressure, how much work is done? Explain.
- 1-4: A 100.0 mL sample of 0.200 M aqueous hydrochloric acid was added to 100.0 mL of 0.200 M aqueous ammonia in a coffee cup calorimeter. The temperature increased from 22.17°C to 23.50°C. In a separate experiment the heat capacity of the calorimeter plus the final solution was found to be 784 JK⁻¹. Calculate ΔH for the reaction: $\text{NH}_3(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NH}_4\text{Cl}(\text{aq})$

Note: ΔE (used in the current text) **and** ΔU are both used to represent the change in internal energy of a system at constant volume.

ASSIGNMENT 2:

- 2-1: Text: 12.25, 12.27 (Answer to 12.27 d) should be -31.1 kJ, 12.29, 12.31, 12.33, 12.35, 12.45, 12.55, 12.59, 12.61, 12.65, 12.67, 12.81, 12.85, 9.11, 9.13, 9.59.

- 2-2: Given the following data:
- | | <u>Bond Enthalpies, kJ.mol⁻¹</u> | <u>Enthalpies of Formation, kJ.mol⁻¹</u> |
|--|---|---|
| | O-H 463 | OH ⁻ (aq) -229.9 |
| | H-H 436 | H ₂ O(l) -285.8 |
| | | H ₂ O(g) -241.8 |

a) Calculate ΔH for each of the following reactions.

- $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$
- $\text{H}_2\text{O}(\text{g}) \rightarrow \text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g})$
- $2\text{H}(\text{g}) + \text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{g})$
- $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- $2\text{H}(\text{g}) \rightarrow \text{H}_2(\text{g})$
- $2\text{H}(\text{g}) + \text{O}(\text{g}) \rightarrow \text{H}_2\text{O}(\text{l})$

2-3: Calculate the average H–S bond energy in H₂S(g) given the data below.

Compound	ΔH_f° , kJ·mol ⁻¹
H ₂ S(g)	-20.1
H(g)	217.9
S(g)	222.8

ASSIGNMENT 3:

3-1: Text: 7.37, 7.39, 7.41, 7.45, 13.3, 13.5, 13.7, 13.9, 13.11, 13.13, 13.15, 13.17, 13.21, 13.23, 13.27, 13.45, 13.47, 13.57, 13.75, 13.79.

3-2: One mole of He(g) enclosed in a cylinder with a moveable piston absorbs 1.00 kJ of heat while expanding against a constant external pressure of 1.00 atmosphere. Calculate ΔH and ΔU for this process. C_p for He(g) = 20.8 JK⁻¹mol⁻¹.

3-3: Calculate the lattice enthalpy of magnesium chloride from the following data:

- enthalpy of formation of Mg(g): 148 kJ·mol⁻¹
- first ionization energy of Mg(g): 736 kJ·mol⁻¹
- second ionization energy of Mg(g): 1450 kJ·mol⁻¹
- enthalpy of formation of Cl(g): 122 kJ·mol⁻¹
- electron-gain enthalpy of Cl(g): -349 kJ·mol⁻¹ (EA in the text)
- enthalpy of formation of MgCl₂(s): -641 kJ·mol⁻¹ (ΔE in the text)

ASSIGNMENT 4:

4-1: Text: 13.29, 13.31, 13.35, 13.43, 13.49, 13.53, 13.75, 13.79, 13.81, 13.87, 15.19, 15.21, 15.59, 15.71.

4-2: Given the following possibilities for $\Delta G^\circ_{\text{rxn}}$, what can you say about the magnitude of K_{eq} for the reaction in each case?

- (a) $\Delta G^\circ_{\text{rxn}} > 0$ (b) $\Delta G^\circ_{\text{rxn}} < 0$ (c) $\Delta G^\circ_{\text{rxn}} = 0$

4-3: At the normal boiling point of ethyl ether, 34.5°C, ΔH° of vaporization is 26.0 kJ·mol⁻¹. Assuming that the volume of 1 mole of liquid ethyl ether is negligible and that ethyl ether vapor behaves as an ideal gas, calculate q , w , ΔU , ΔS , and ΔG for the reversible vaporization of 1 mole of ethyl ether at a constant pressure of 1 atm.

ASSIGNMENT 5:

5-1: At what temperature will the vapour pressure of water equal 600 Torr? Assume the enthalpy and entropy change to be independent of temperature.

5-2: The standard free energy of formation of benzene is positive. Benzene is a common, stable organic solvent. Is there a conflict between these facts? If so, explain why the two statements can still be simultaneously true.

5-3: For the reaction: $\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}(\text{s}) \leftrightarrow \text{Li}_2\text{SO}_4(\text{s}) + \text{H}_2\text{O}(\text{g})$
 $\Delta G^\circ = 15.2 \text{ kJ mol}^{-1}$ at 298 K. Calculate the pressure of H₂O(g) in torr, in equilibrium with Li₂SO₄·H₂O(s) and Li₂SO₄(s) at 298 K. (Pressure unit conversion: 1 atm = 1 torr)

5-4: For each of the reaction listed below:

- Use tabulated data to calculate ΔG° at 298 K
- Use tabulated data to calculate ΔH° and ΔS° at 298 K and verify that $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
- Will the reaction occur spontaneously at 298 K with all reactants and products in their standard states? If so, which factor (enthalpy or entropy) provides the principle driving force?
- Where the reaction will not occur spontaneously at 298 K, determine whether it would become

spontaneous at some higher or lower temperature. For each reaction determine the range of temperatures, if any, over which it will be spontaneous.

- i. $4\text{HCl(g)} + \text{O}_2\text{(g)} \rightarrow 2\text{H}_2\text{O(g)} + 2\text{Cl}_2\text{(g)}$
- ii. $\text{H}_2\text{(g)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{HCl(g)}$
- iii. $\text{C(graphite)} \rightarrow \text{C(diamond)}$

ASSIGNMENT 6:

6-1: Text: 18.1, 18.3, 18.5, 18.7, 18.9, 18.13, 18.15.

6-2: Balance each of the following equations, identifying the oxidizing agent and the reducing agent in each case. All ions are in aqueous solution.

- a) $\text{Cr}_2\text{O}_7^{2-} + \text{C}_2\text{H}_4\text{O} \rightarrow \text{C}_2\text{H}_4\text{O}_2 + \text{Cr}^{3+}$ (acidic solution)
- b) $\text{PbO}_2\text{(s)} + \text{Cl}^- \rightarrow \text{ClO}^- + \text{Pb(OH)}_3^-$ (basic solution)
- c) $\text{H}_2\text{S}_2\text{O}_3 \rightarrow \text{S}_8\text{(s)} + \text{HSO}_4^-$ (acidic solution)
- d) $\text{HO}_2^- + \text{Cr(OH)}_3^- \rightarrow \text{CrO}_4^{2-}$ (basic solution)

ASSIGNMENT 7:

7-1: Text: 18.19, 18.21, 18.25, 18.27, 18.31, 18.67, 18.77, 18.81, 18.85.

7-2: For each of the following reactions,

- a) Write the oxidation and reduction half-reactions;
- b) Determine the number of electrons transferred in the equation as written;
- c) Use standard reduction potentials to calculate E° ;
- d) Tell whether the reaction is spontaneous as written under standard conditions
 - a) $\text{Fe}^{2+}\text{(aq)} + \text{Ag}^+\text{(aq)} \rightarrow \text{Fe}^{3+}\text{(aq)} + \text{Ag(s)}$
 - b) $\text{Cu(s)} + \text{AgCl(s)} \rightarrow \text{Cu}^{2+}\text{(aq)} + 2\text{Ag(s)} + 2\text{Cl}^-\text{(aq)}$

ASSIGNMENT 8:

8-1: Text: 18.35, 18.37, 18.41, 18.43, 18.45, 18.63, 18.69, 18.91.

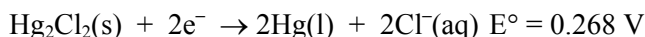
8-2: Use tabulated data to calculate ΔG° and K_{eq} for each of the following reactions:

- a) $2\text{Ag(s)} + \text{F}_2\text{(g)} \rightarrow 2\text{Ag}^+\text{(aq)} + 2\text{F}^-\text{(aq)}$
- b) $\frac{1}{2}\text{H}_2\text{(g)} + \text{Fe}^{3+}\text{(aq)} \rightarrow \text{Fe}^{2+}\text{(aq)} + \text{H}^+\text{(aq)}$

8-3: Calculate E for the half-reactions:

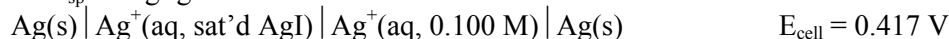
- a) $\text{H}^+\text{(aq, } 1.00 \times 10^{-7} \text{ M)} + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2\text{(g, 1 atm)}$
- b) $\text{H}^+\text{(aq, } 1.00 \times 10^{-14} \text{ M)} + \text{e}^- \rightarrow \frac{1}{2}\text{H}_2\text{(g, 1 atm)}$

8-4: A hydrogen electrode having a $\text{H}_2\text{(g)}$ pressure of 1.00 atm is combined with a standard calomel electrode, whose half-reaction is



- (a) If the cell potential is 0.800 V, find the pH of the solution surrounding the hydrogen electrode.
- (b) Calculate the cell potential when the hydrogen electrode is immersed in a neutral solution.

8-5: Calculate the K_{sp} of AgI given the concentration cell below.



ASSIGNMENT 9:

9-1: Text: 18.49, 18.53, 18.55, 18.57, 18.59, 18.73, 18.87, 14.9, 14.15.

9-2: Calculate the minimum decomposition voltage in the electrolysis of 0.200 M $\text{CuBr}_2\text{(aq)}$.

- 9-3: Sodium metal is produced commercially by the electrolysis of molten sodium chloride. Calculate the mass of sodium and the volume of chlorine gas measured at 1 atm and 25°C produced by a current of 20.0 amperes in 1.00 hour.
- 9-4: How long will it take to produce a solution of pH 2.00 by electrolysis of 500.0 mL of 0.100 M $\text{AgNO}_3(\text{aq})$ by using a constant current of 0.240 Amperes?
- 9-5: The reaction: $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g})$ is found experimentally to be first-order in O_2 and second-order in NO . Beginning with $1.88 \times 10^{-3} \text{ molL}^{-1}$ of $\text{O}_2(\text{g})$ and $2.00 \times 10^{-1} \text{ molL}^{-1}$ of $\text{NO}(\text{g})$, to what fraction of the initial rate has the rate decreased when
 (a) half of the initial $\text{O}_2(\text{g})$ has been consumed?
 (b) half of the initial $\text{NO}(\text{g})$ has been consumed?

ASSIGNMENT 10:

- 10-1: Text: 14.17, 14.19, 14.21, 14.23, 14.25, 14.27, 14.29, 14.31, 14.51, 14.61, 14.63, 14.65, 21.63, 21.79, 21.81.
- 10-2: Sulphuryl chloride, SO_2Cl_2 , decomposes on heating according to the equation:

$$\text{SO}_2\text{Cl}_2(\text{g}) \rightarrow \text{SO}_2(\text{g}) + \text{Cl}_2(\text{g})$$
 A study of the reaction at 329°C led to the following results:

Time (min.)	$[\text{SO}_2\text{Cl}_2], \text{M}$	Time (minutes)	$[\text{SO}_2\text{Cl}_2], \text{M}$
0	2.02×10^{-3}	315	8.45×10^{-4}
76	1.64×10^{-3}	410	6.70×10^{-4}
200	1.17×10^{-3}	560	4.31×10^{-4}

Use a graphical method to determine the rate law and the rate constant at 329°C.

- 10-3: A charcoal sample from Stonehenge, an ancient megalithic site near Salisbury in Southern England, is analyzed by carbon-14 dating. A 1.00-g sample gave 9.65 disintegrations per minute. A 1.00-g sample of carbon from a modern source gave 18,400 disintegrations in 20.0 hours. How old is the charcoal from Stonehenge?

ASSIGNMENT 11:

- 11-1: Text: 14.3, 14.7, 14.35, 14.37, 14.41, 14.45, 14.57, 14.59, 14.67, 14.81, 14.83, 14.85, 14.89.
- 11-2: The reaction: $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}); \Delta U = -113 \text{ kJ}$ is believed to occur by the following mechanism:

$$2\text{NO}(\text{g}) \leftrightarrow \text{N}_2\text{O}_2(\text{g}) \quad (\text{rapid equilibrium, } K)$$

$$\text{N}_2\text{O}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{NO}_2(\text{g}) \quad (\text{slow, } k)$$
 (a) Derive the rate law predicted by this mechanism.
 (b) Draw the energy profile (plot of energy versus reaction coordinate) for the reaction, clearly labelling all intermediates.

ASSIGNMENT 12:

- 12-1: Text: 14.49, 14.55.