Welcome to ChE 102: Chemistry for Engineers!

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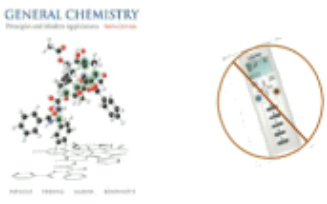
Course objectives

- Knowledge of core chemistry concepts required for engineering programs.
- Topics covered:
  - The nature of matter; chemical compounds and reactions.
  - Ideal and real gases; liquids and solids; phase diagrams; solutions and their properties.
  - Chemical equilibria; solubility.
  - Reactions in aqueous solution; electrochemistry.
  - Reaction kinetics.
- Applying and extending this knowledge to problem synthesis and problem solving.

Some useful information

…..PLEASE READ THE SYLLABUS!

- Course material and lecture slides will be posted on LEARN



- GOOD NEWS! There are no lectures or tutorials during mid-term week for first year students!
- BAD NEWS… we need to make-up these lectures.
- Make up lectures are scheduled for Friday, September 19th, October 3rd and October 31st from 12:30 – 1:20 in DWE-2527.

COURSE GRADING SCHEME

Component	Weight
Weekly assignment	5%
Weekly tutorial	10%
Mid-term examination*	25%
Final examination*	60%

*the examinations will be **multiple choice**
*you may use calculators and 1 note sheet on the exams!
*a table of constants and conversion factors will be provided!
*a periodic table will be provided!

Your weighted examination grade must be >50% (42.5/85) to pass the course!

Your midterm is 6:30 – 8:00 PM on Friday, Oct. 17th!

LECTURE

- You are expected to be present both physically and mentally.
- Ask questions and participate!

TUTORIALS

- Your opportunity to work with the course content and ask questions.
- Run by TA.
- Attend your assigned tutorial!

- My office hours E6-5020
  Monday 3:30 – 5:30 or by appointment.

- TA office hours
- Engineering Help Sessions E2-1310
  Wednesday and Thursday 6:30-8:30
- WEEF TAs E2-1318
  - Don Tu dntu@uwaterloo.ca
  - Mohamad Chanaa mzchanaa@uwaterloo.ca
  - Keven Le k3le@uwaterloo.ca
  - Zhao Want zy22wang@uwaterloo.ca

STAYING OUT OF TROUBLE!

- You are expected to be aware of what constitutes an academic offense (read Policy #71).
- All academic offences, including first offences, will be reported to the Engineering First-Year office.
- For ChE102 keep in mind…
  - You must submit personally prepared and hand-written solutions for assignment and tutorial problems.
  - Even if you have studied together, you must prepare an *individual* solution.

Unit Conversions

Objective: By the end of today's class you will be able to convert between units of length, mass, volume, force, temperature, etc. and any combination thereof.

Conversion Factors

Length	1 m	10^{10} Å	39.370 in	3.28084 ft	6.21371×10^{-4} mi
Area	1 m^2	10^4 cm^2	1550.0031 in^2	10.7639 ft^2	2.47105×10^{-4} acre
Volume	1 m^3	1000 L	6.10237×10^4 in^3	264.172 gal(US)	219.969 gal(Imp)
Mass	1 kg	2.20462 lb_m	35.274 oz	10^{-3} metric tonnes	
Density	1 g/cm^3	1000 kg/m^3	1000 g/L	62.4280 lb_m/ft^3	8.34541 lb_m/gal(US)
Velocity	1 m/s	3.6 km/h	3.2808 ft/s	196.850 ft/min	2.23694 mi/h
Force	1 kg·m/s^2 (N)	10^5 g·cm/s^2 (dyne)	0.224809 lb_f	0.10197 kg_f	7.23301 lb_m·ft/s^2
Pressure	1 atm	101325 kg/m·s^2 (Pa)	1.01325 bar	14.6959 lb_f/in^2 (psi)	760 mmHg (torr)
Energy	1 kg·m^2/s^2 (J)	9.4782×10^{-4} Btu	0.23885 cal	0.737561 ft·lb_f	6.24145×10^{18} eV
Power	1 J/s (W)	1 kg·m^2/s^3	3.4121 Btu/h	1.34102×10^{-3} hp	10^7 erg/s
Specific Heat	1 kJ/kg·K	0.23885 cal/g·°C	0.13269 cal/g·°F	0.23885 Btu/lb_m·°F	185.863 ft·lb_f/lb_m·°F
Mole	1 kmol	1000 mol	10^6 mmol	10^9 µmol	2.20462 lb-mol
Concentration	1 wt. %	0.01 mass fraction	10 ppt	10^4 ppm	10^7 ppb

Example 1

"A Boeing 767 airplane flying for Air Canada on July 23, 1983 diminished its fuel supply only an hour into its flight. It was headed to Edmonton from Montreal, but it received low fuel pressure warnings in both fuel pumps at an altitude of 41,000 feet; engine failures followed soon after. This incident was due partially to the airplane's fuel indication system, which had been malfunctioning. Maintenance workers resorted to manual calculations in order to fuel the craft. They knew that 22,300 kg of fuel was needed, and they wanted to know how much in liters should be pumped. They used 1.77 as their density ratio in performing their calculations. However, 1.77 was given in pounds per liter, not kilograms per liter." What percentage of the needed fuel did the plane leave Montreal with?

$1/2.20462 \approx 45.3\%$

Units are important!

- Write units everywhere and always.
- Be clear with units! Which of the following would you not use and why…..

  $9.8 ms^{-2}$ $9.8\ m\ s^{-2}$ $9.8\ m{\cdot}s^{-2}$ $9.8\ m/s^2$
- Format guidelines
  - Numbers and units are in roman (normal, not italic) type.
  - Hit *ctrl+shift+*<space> to get a non-breaking space in most programs.
  - Degrees and percent do not have a space after the number (so 99% and 45°) but temperature units do (0 °C = 273.15 K).

$9.8 ms^{-2}$ looks like millisecond

Example 2

Convert 23 $lb_m{\cdot}ft{\cdot}min^{-2}$ into $kg{\cdot}cm{\cdot}s^{-2}$.

Bases: $23\ \frac{lbm\,ft}{min^2}$ to $\frac{kg\,cm}{s^2}$

Data: 2.20 lb = 1 kg

3.28 ft = 1 m = 100 cm

60 s = 1 min

$$23\ \frac{lbm\,ft}{min^2} \times \frac{1\ kg}{2.20\ lb} \times \frac{100\ cm}{3.28\ ft} \times \left(\frac{1\ min}{60\ s}\right)^2$$

Temperature conversions

- For a **temperature value** use an equation.

  $T(°C) = 5 \times (T(°F) - 32) / 9$

  $T(°F) = (9/5)\ T(°C) + 32$

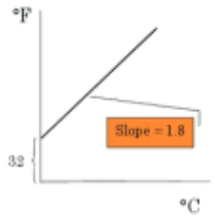
  $T(K) = T(°C) + 273.15$

  $T(°R) = T(°F) + 459.67$

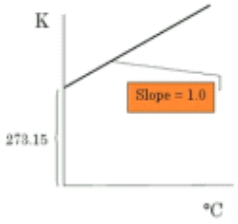
  Given on exam!
- For a **change in temperature** use a conversion factor.

  $\frac{1\ K}{1.8\ °R}, \frac{1\ K}{1.8\ °F}, \frac{1\ °C}{1.8\ °F}, \frac{1\ °C}{1.8\ °R}, \frac{1\ °C}{1\ K}, \frac{1\ °F}{1\ °R}$

$T(°F) = 1.8\ T(°C) + 32$



$T(K) = T(°C) + 273.15$



EXAMPLE 3

Convert 100 °F into °C.

$T(°C) = 5 \times (100 - 32)/9$

Answer:

EXAMPLE 4

What is the temperature interval between 100 and 200 °C, expressed in °F?

$$100°C \times \frac{1.8°F}{1°C} = 180°F$$

Answer:

Example 5

Stainless steel, type 304 has a thermal conductivity k of 0.067 $cal \cdot s^{-1} \cdot cm^{-1} \cdot °C^{-1}$. What is this value expressed in $Btu \cdot h^{-1} \cdot ft^{-1} \cdot °F^{-1}$?

A. 3.87 B. 4.94 C. 9.1 D. 16.2 E. 29.6

$$0.067 \frac{cal}{s \cdot cm \cdot °C} \times \frac{9.478 \times 10^{-4}}{0.239} \times \frac{3600 s}{1 h} \times \frac{5}{9} \times \frac{100}{3.281}$$

Example 6

To determine the volume of an irregularly shaped glass vessel, the vessel is weighed empty (121.3 g) and again when filled with carbon tetrachloride (283.2 g). What is the volume of the vessel, in cubic inches, given that 1 L of carbon tetrachloride weights 3.51 lb?

Answer:

Example 7

Things have been financially difficult for you over the fall term and you are faced with cashing the inheritance left to you by your grandfather – a California gold nugget weighing 12.3 grains. You decide you will convert the gold nugget to Tim Horton Timbits® and at least you won't starve. You do a Google search and find that melted down raw gold from nuggets is currently bringing $710 USD/troy ounce; the exchange rate on the USD is 1 USD = 1.1263 CA; and that you can get 40 Timbits® for $4.49 CA. You also find out from GoldFeverProspecting.com that 31.1 grams = 1 troy ounce and that 1 gram = 15.43 grains. How many Timbits® can you get by cashing in your inheritance?

A) 4 B) 162 C) 182 D) 2817 E) 5768

Example 8

You are trying to decide which of two automobiles to buy. The first costs $9500 and has a rated gasoline mileage of 28 mpg (miles per US gallon). The second car is of European manufacture and costs $12700 and has a rated gas mileage of 19 km·L^{-1}. If the cost of gasoline is $1.10 gal^{-1} and the cars actually deliver their rated mileage, approximately how many thousands of miles would you have to drive to recover the cost difference between the two cars?

A. 45 B. 90 C. 135 D. 180 E. 215

Suggested Readings

- 1.4 Measurement of Matter
- 1.5 Density and Percent Composition