### Some useful constants and relationships:

- Specific heat capacities (in J/g·K): H$_2$O(l) = 4.184; Al($\alpha$) = 0.900; Cu($\alpha$) = 0.387; Steel($\alpha$) = 0.45
- 101.325 J = 1 L atm  
  1 atm = 760 Torr  
  1 J = 1kg·m²/s²  
  1 eV = 1.6022 x 10⁻¹⁹ J
- R = Ideal gas constant: 0.08206 L atm mol⁻¹ K⁻¹ = 8.31451 J mol⁻¹ K⁻¹
- Avogadro constant: 6.022 x 10²³ molecule⁻¹
- Planck's constant = h = 6.66261 x 10⁻³⁴ J·s
- c = Speed of light: 3.00 x 10⁸ m/s
- R$_{II}$ = 1.097 x 10⁻² nm⁻¹
- C₂ = Second radiation constant = 1.44 x 10⁻² K m

The formula for the emitted power $E$ is given by:

$$E = \frac{h c}{\lambda} = \frac{1}{\lambda} = R_{II} \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

where $n_1$ and $n_2$ are the refractive indices of the two media, and $R_{II}$ is the second radiation constant.
1. A rocket fuel is composed of two liquids, hydrazine (N$_2$H$_4$) and dinitrogen tetraoxide (N$_2$O$_4$), which ignite on contact to form nitrogen gas and water vapor via the following equation:

$$2\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow 3\text{N}_2(g) + 4\text{H}_2\text{O}(g)$$

If 3.12 mol of N$_2$H$_4$ and 2.17 mol of N$_2$O$_4$ are mixed to form the rocket fuel:

(a) What is the limiting reactant (10 pts):

If the limiting reactant is N$_2$H$_4$, we would need:

$$\frac{3.12 \text{ mol N}_2\text{H}_4}{2 \text{ mol N}_2\text{H}_4} \times 1 \text{ mol N}_2\text{O}_4 = 1.5 \text{ mol N}_2\text{O}_4. \quad \text{We have 2.17 mol N}_2\text{O}_4 \text{ (excess), so N}_2\text{H}_4 \text{ is the limiting reactant.}$$

(b) How many grams of nitrogen gas form in the above reaction? Set up but do not solve. (10 pts)

Grams of nitrogen gas formed =

$$\frac{3.12 \text{ mol N}_2\text{H}_4}{2 \text{ mol N}_2\text{H}_4} \times 3 \text{ mol N}_2 \times \frac{28.0 \text{ g N}_2}{1 \text{ mol N}_2}$$

Numerically, this calculates to 131.0 g. 10 points if all correct. 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of N$_2$.

If they incorrectly put N$_2$O$_4$ as the limiting reactant in part (a), then their answer should be:

$$\frac{2.17 \text{ mol N}_2\text{O}_4}{1 \text{ mol N}_2\text{O}_4} \times 3 \text{ mol N}_2 \times \frac{28.0 \text{ g N}_2}{1 \text{ mol N}_2}.$$

In this case, they get 10 points if all correct, 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of N$_2$. This was Sample Problem 3.11 in the text.

2. Write balanced equations for each of the following by inserting the correct coefficients in the blanks (5 pts each): This was homework problem 3.37. 5 points each, all or nothing. OK to use fractions. OK to leave it blank instead of putting a “1”

(a) $16\underline{\text{Cu}}(s) + 1\underline{\text{S}}(s) \rightarrow 8\underline{\text{Cu}_2}\text{S}(s)$
(b) $\text{P}_4\text{O}_{10(s)} + 6\text{H}_2\text{O(l)} \rightarrow 4\text{H}_3\text{PO}_4(l)$

3. Calculate the following quantities (set up but do not solve): (10 pts each) This was homework problem 3.68
(a) Grams of solute in 185.8 mL of 0.267 M calcium acetate (MW = 158.2 g/mol)

$$\frac{0.267 \text{ mol Ca(C}_2\text{H}_3\text{O}_2)_2}{\text{L}} \times \frac{185.8 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{158.2 \text{ g}}{\text{mol Ca(C}_2\text{H}_3\text{O}_2)_2}$$

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on bottom or used 0.1858 L on top)

(b) Molarity of 500. mL of solution containing 21.1 g of potassium iodide (MW = 166.0 g/mol)

$$\frac{21.1 \text{ g KI}}{166.0 \text{ g}} \times \frac{\text{mol KI}}{\text{mol KI}} \times \frac{1000 \text{ mL}}{500 \text{ mL}} \times \frac{1 \text{ L}}{1 \text{ L}}$$

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on top or used 0.500 L on bottom)
<table>
<thead>
<tr>
<th>Name:</th>
<th>Version B Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student ID Number:</td>
<td></td>
</tr>
<tr>
<td>Section Number:</td>
<td></td>
</tr>
</tbody>
</table>

### Some useful constants and relationships:

- Specific heat capacities (in J/g·K): 
  - \( \text{H}_2\text{O}(l) = 4.184 \) J/(g·K)  
  - \( \text{Al}(s) = 0.900 \) J/(g·K)  
  - \( \text{Cu}(s) = 0.387 \) J/(g·K)  
  - \( \text{Steel}(s) = 0.45 \) J/(g·K)

- \( 101.325 \text{ J} = 1 \text{ L atm} \)
- \( 1 \text{ atm} = 760 \text{ Torr} \)

- Planck's constant \( h = 6.6261 \times 10^{-34} \) J·s
- Speed of light \( c = 3.00 \times 10^8 \) m/s
- C2 = second radiation constant = 1.44 \times 10^{-2} \) K·m

\[
T \lambda_{\text{max}} = \frac{1}{5} C_2 \quad \text{Emitted power (W)} \quad \lambda = \frac{h}{E} \quad c = \lambda \nu
\]

\[
\frac{1}{\lambda} = R_{\text{H}} \left( \frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad E = h \nu \quad E = \frac{hc}{\lambda} \quad \text{E (in Joules)} = -2.18 \times 10^{-18} \left( \frac{Z^2}{n^7} \right)
\]
1. A rocket fuel is composed of two liquids, hydrazine (N$_2$H$_4$) and dinitrogen tetraoxide (N$_2$O$_4$), which ignite on contact to form nitrogen gas and water vapor via the following equation:

$$2N_2H_4(l) + N_2O_4(l) \rightarrow 3N_2(g) + 4H_2O(g)$$

If 3.08 mol of N$_2$H$_4$ and 2.23 mol of N$_2$O$_4$ are mixed to form the rocket fuel:

(a) What is the limiting reactant (10 pts): N$_2$H$_4$

If the limiting reactant is N$_2$H$_4$, we would need:

$$\frac{3.08 \text{ mol } N_2H_4 \times 1 \text{ mol } N_2O_4}{2 \text{ mol } N_2H_4} = \frac{3.08}{2} \approx 1.5 \text{ mol } N_2O_4.$$ We have 2.23 mol N$_2$O$_4$ (excess), so N$_2$H$_4$ is the limiting reactant.

(b) How many grams of nitrogen gas form in the above reaction? Set up but do not solve. (10 pts)

Grams of nitrogen gas formed =

$$\frac{3.08 \text{ mol } N_2H_4 \times 3 \text{ mol } N_2}{2 \text{ mol } N_2H_4} \times \frac{28.0 \text{ g } N_2}{1 \text{ mol } N_2}$$

Numerically, this calculates to 129.4 g. 10 points if all correct. 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of N$_2$.

If they incorrectly put N$_2$O$_4$ as the limiting reactant in part (a), then their answer should be:

$$\frac{2.23 \text{ mol } N_2O_4 \times 3 \text{ mol } N_2}{1 \text{ mol } N_2O_4} \times \frac{28.0 \text{ g } N_2}{1 \text{ mol } N_2}.$$ In this case, they get 10 points if all correct, 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of N$_2$. This was Sample Problem 3.11 in the text.

2. Write balanced equations for each of the following by inserting the correct coefficients in the blanks (5 pts each): This was homework problem 3.37. 5 points each, all or nothing. OK to use fractions. OK to leave it blank instead of putting a “1”

(a) $1\_P_4O_{10(s)} + 6\_H_2O_{(l)} \rightarrow 4\_H_3PO_{4(l)}$

(b) $1\_B_2O_3(s) + 6\_NaOH_{(aq)} \rightarrow 2\_Na_3BO_3(aq) + 3\_H_2O_{(l)}$
3. Calculate the following quantities (set up but do not solve): (10 pts each) This was homework problem 3.68
(a) Grams of solute in 237.6 mL of 0.159 M calcium acetate (MW = 158.2 g/mol)

\[
\frac{0.159 \text{ mol Ca(C}_2\text{H}_3\text{O}_2)_2}{L} \times \frac{237.6 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{158.2 \text{ g}}{\text{mol Ca(C}_2\text{H}_3\text{O}_2)_2}
\]

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on bottom or used 0.2376 L on top)

(b) Molarity of 300. mL of solution containing 48.2 g of potassium iodide (MW = 166.0 g/mol)

\[
\frac{48.2 \text{ g KI}}{166.0 \text{ g}} \times \frac{\text{mol KI}}{300 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}}
\]

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on top or used 0.300 L on bottom)
Some useful constants and relationships:
Specific heat capacities (in J/g K): $H_2O(l) = 4.184; \text{Al}(s) = 0.900; \text{Cu}(s) = 0.387; \text{Steel}(s) = 0.45$
101.325 J = 1 L atm
1 atm = 760 Torr
1 eV = 1.6022 x $10^{-19}$ J
R = Ideal gas constant: 0.08206 L atm mol$^{-1}$ K$^{-1}$ = 8.31451 J mol$^{-1}$ K$^{-1}$
Avogadro constant: 6.022 x $10^{23}$ mole$^{-1}$
Planck's constant $= h = 6.6261 \times 10^{-34}$ J s
$c =$ speed of light: 3.00 x $10^8$ m/s
$R_H =$ second radiation constant $= 1.44 \times 10^2$ K m

$$T\lambda_{\text{max}} = \frac{1}{5} C_2 \frac{\text{Emissivity (W)}}{\text{Surface area (m)}} = (\text{constant}) T^4$$
$$E = \hbar \nu$$
$$E = \frac{hc}{\lambda}$$
$$E \text{(in Joules)} = -2.18 \times 10^{-18} \left(\frac{Z^2}{n^2}\right)$$
1. A rocket fuel is composed of two liquids, hydrazine ($\text{N}_2\text{H}_4$) and dinitrogen tetraoxide ($\text{N}_2\text{O}_4$), which ignite on contact to form nitrogen gas and water vapor via the following equation:

$$2\text{N}_2\text{H}_4(l) + \text{N}_2\text{O}_4(l) \rightarrow 3\text{N}_2(g) + 4\text{H}_2\text{O}(g)$$

If 4.12 mol of $\text{N}_2\text{H}_4$ and 3.93 mol of $\text{N}_2\text{O}_4$ are mixed to form the rocket fuel:

(a) What is the limiting reactant (10 pts): $\text{N}_2\text{H}_4$

If the limiting reactant is $\text{N}_2\text{H}_4$, we would need:

$$\frac{4.12 \text{ mol } \text{N}_2\text{H}_4 \times 1 \text{ mol } \text{N}_2\text{O}_4}{2 \text{ mol } \text{N}_2\text{H}_4} = \frac{4.12}{2} = 2 \text{ mol } \text{N}_2\text{O}_4.$$ 

We have 3.93 mol $\text{N}_2\text{O}_4$ (excess), so $\text{N}_2\text{H}_4$ is the limiting reactant.

(b) How many grams of nitrogen gas form in the above reaction? Set up but do not solve. (10 pts)

Grams of nitrogen gas formed =

$$\frac{4.12 \text{ mol } \text{N}_2\text{H}_4 \times 3 \text{ mol } \text{N}_2}{2 \text{ mol } \text{N}_2\text{H}_4} \times \frac{28.0 \text{ g } \text{N}_2}{1 \text{ mol } \text{N}_2}.$$ 

Numerically, this calculates to 173.0 g. 10 points if all correct. 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of $\text{N}_2$.

If they incorrectly put $\text{N}_2\text{O}_4$ as the limiting reactant in part (a), then their answer should be:

$$\frac{3.93 \text{ mol } \text{N}_2\text{O}_4 \times 3 \text{ mol } \text{N}_2}{1 \text{ mol } \text{N}_2\text{O}_4} \times \frac{28.0 \text{ g } \text{N}_2}{1 \text{ mol } \text{N}_2}.$$ 

In this case, they get 10 points if all correct, 5 points if all correct but they use 14.0 g instead of 28.0 g for MW of $\text{N}_2$. This was Sample Problem 3.11 in the text.

2. Write balanced equations for each of the following by inserting the correct coefficients in the blanks (5 pts each): This was homework problem 3.37. 5 points each, all or nothing. OK to use fractions. OK to leave it blank instead of putting a “1”

(a) $1\underline{\text{B}}_2\text{O}_3(s) + 6\underline{\text{NaOH}}_{(aq)} \rightarrow 2\underline{\text{Na}}_3\text{BO}_3_{(aq)} + 3\underline{\text{H}}_2\text{O}(l)$

(b) $4\underline{\text{CH}}_3\text{NH}_2(g) + 9\underline{\text{O}}_2(g) \rightarrow 4\underline{\text{CO}}_2(g) + 10\underline{\text{H}}_2\text{O}(g) + 2\underline{\text{N}}_2(g)$
3. Calculate the following quantities (set up but do not solve): (10 pts each) *This was homework problem 3.68*

(a) Grams of solute in 38.6 mL of 0.572 M calcium acetate (MW = 158.2 g/mol)

\[
\frac{0.572 \text{ mol Ca(C}_2\text{H}_3\text{O}_2)_2}{\text{L}} \times \frac{38.6 \text{ mL}}{1 \text{ L}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{158.2 \text{ g}}{\text{mol Ca(C}_2\text{H}_3\text{O}_2)_2}
\]

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on bottom or used 0.0386 L on top)

(b) Molarity of 200. mL of solution containing 23.7 g of potassium iodide (MW = 166.0 g/mol)

\[
\frac{23.7 \text{ g KI}}{166.0 \text{ g}} \times \frac{\text{mol KI}}{200 \text{ mL}} \times \frac{1000 \text{ mL}}{1 \text{ L}}
\]

10 points for correct expression
give them 8 points if expression is correct but they forget to convert mL to L (1000 on top or used 0.200 L on bottom)