

**University of Ottawa**  
**Faculty of Engineering - Department of Mechanical Engineering**

**ENGINEERING MATERIALS II**  
**MCG 2361**

**Exam 1**

Student Name: \_\_\_\_\_ Student Number: \_\_\_\_\_

The two questions are mandatory and are worth a total of 15 points out of 30 points for this midterm. A facultative bonus question worth an additional 3 points is available at the end of this exam.

**Quality of presentation will be evaluated using negative marking;** a maximum of 3 marks will be subtracted for any copy where explanations are not clear, text is difficult to read and/or diagrams are unclear, too small or of poor quality.

Good luck!

Arnaud Weck

### Question 1 (7 marks)

In the course we discussed the 2 following equations for the number average molar mass  $\overline{M}_n$  and the weight average molar mass  $\overline{M}_w$ , both in g/mol:

$$\overline{M}_n = \frac{\sum n_i M_i}{\sum n_i} = \frac{\sum w_i}{\sum n_i} = \frac{W}{\sum n_i}$$

$$\overline{M}_w = \frac{\sum w_i M_i}{\sum w_i} = \frac{\sum w_i M_i}{W} = \frac{\sum n_i M_i^2}{\sum n_i M_i}$$

where  $n$  are numbers of moles,  $M$  are molar masses,  $W$  are sample masses and  $w$  are fractional masses.

Molecular weight data for some polymers are tabulated below:

Molecular Weight Range (g/mol)	$n_i$	$w_i$
15,000-30,000	0.010	0.003
30,000-45,000	0.040	0.018
45,000-60,000	0.110	0.071
60,000-75,000	0.240	0.199
75,000-90,000	0.270	0.273
90,000-105,000	0.160	0.192
105,000-120,000	0.120	0.166
120,000-135,000	0.050	0.078

- a) Calculate the weight average molecular mass. **(2 mark)**
- b) It is known that this material's degree of polymerization is 783. Which one of the polymers listed below is this polymer and why? **(3 mark)**  
i) polyethylene, ii) polypropylene, ii) polystyrene
- c) Is it possible to have  $M_n = M_w$  and if so, what does it mean physically? Explain briefly. **(2 mark)**

## Question 2 (8 marks)

- a) Explain what the glass transition temperature  $T_g$  is. **(2 mark)**
- b) Explain why the glass transition temperature  $T_g$  is always smaller than the melting temperature  $T_m$ . **(2 mark)**
- c) Clearly identify the states of the polymer above and below  $T_g$  and  $T_m$  for an amorphous and for a semi-crystalline sample. **(4 mark)**

## BONUS question (3 marks)

Describe what tempered glass is and how it is made. Use a diagram if necessary. Also, explain precisely the mechanisms that lead to the better performance of tempered glass compared to normal glass. Describe your answer in terms of **stresses** and **temperatures** at various locations in the material.

**End of the Exam**