CHEM-E2130 POLYMER PROPERTIES
Examination: 08.12.2022
9:00-13:00
6 questions, max 44 points

This is an "open book" examination. Thus handouts&slides&internet are allowed in the examination. **Still, the answers must be based on the course material.**

Q1)

In an ideal membrane osmometry experiment, a plot of π/cRT against c gives a straight line with intercept $1/\bar{M}$. Similarly, an ideal light scattering experiment at zero viewing angle yields a straight line plot of Hc/t against c with intercept $1/\bar{M}$. For a given polymer sample, solvent and temperature,

A) Are the $\bar{M}$ values the same from osmometry and light scattering? **(2 points)**
B) Are the slopes of the straight line plots the same? Give all reasonable explanations **(2 points)**

Q2)

A polymer chemist has prepared a 2 g-sample of a solid polymer and wants to characterize its thermal properties by thermogravimetry (TGA), differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA).
Explain how and which of these techniques would be useful to answer to the following questions and obtain information about polymer:

A. What is the melting point (if the polymer melts)? **(2 points)** DSC
B. Is the polymer pure? **(2 points)** TGA
C. Is the polymer stable over a certain range of temperature? **(2 points)** TGA
D. When cooling from its liquid form, if melting occurs, does the material crystallize back to its original solid form? **(2 points)** DMA
E. What is the glass transition temperature (Tg) of the polymer? **(2 points)** DMA ~~DSC~~

Q3)

A) Which type of polymers are more easily hydrolyzed? **(1 point)**
B) Which stabilizer can be used for improving the stability of polymers against radiation-oxidative degradation? **(1 point)**
C) By which microscopy technique we can study the topography of a non-conductive sample? **(1 point)**
D) What is the difference between SEM and TEM techniques? **(2 points)**

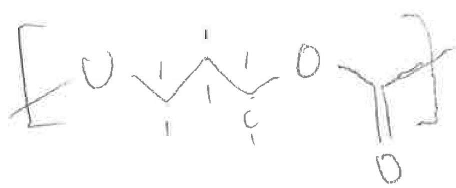
Q4

Poly(trimethylene carbonate) (PTMC) is an enzymatically degradable polymer that dissolves for example in chloroform. The solubility parameter δ of a polymer can be calculated through summation of the molar attraction constants Fi, for each chemical group in the polymer repeating unit, and dividing that with the molar volume of the polymer.

A. Calculate the solubility parameter δ for PTMC using Van Krevelen constants at room temperature. ρ PTMC = 1.31 g/cm3 **(2 points)**
B. By exposing PTMC to gamma irradiation, the polymer can be crosslinked. Describe the difference between how a PTMC polymer chain and a crosslinked PTMC network behave when immersed in chloroform. **(2 points)**
C. You have an unknown sample of PTMC. What kind of information can you get about the sample by using gel permeation chromatography and why is the solubility in chloroform relevant for this method? **(1 point)**

Table 3-2 Molar Attraction Constants at 25°C

Group	Molar Attraction Constant, F $(MPa)^{1/2}$ cm^3 mol^{-1}			
	Small[16]	Hoy[19]	Van Krevelen[20]	
$-CH_3$	438	303	420	
$-CH_2-$	272	269	280	3
$>CH-$	57	176	140	
$>C<$	-190	65.5	0	
$-CH(CH_3)-$	495	(479)	560	
$-C(CH_3)_2-$	686	(672)	840	
$-CH=CH-$	454	497	444	
$>C=CH-$	266	422	304	
Phenyl	1504	1398	1517	
p-Phenylene	1346	1442	1377	
–O– (ether)	143	235	256	1
–OH	—	462	754	
–CO– (ketone)	563	538	685	
–COO– (ester)	634	668	512	1
–OCOO– (carbonate)	—	(904)	767	



$C_4H_6O_3$

Q5)

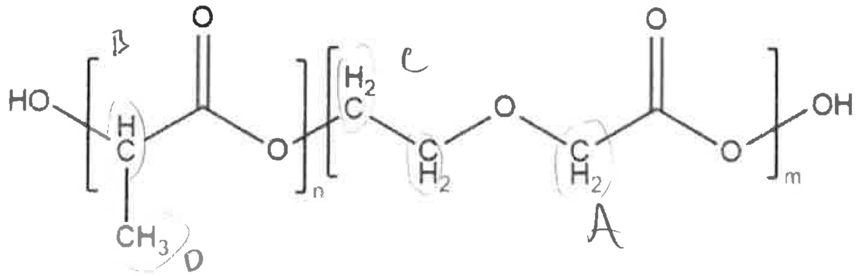
There is a novel polymer available for the production line with the following properties: melt viscosity at 140 °C is 1×10^5 Pa×s, glass transition temperature 110 °C but some decomposition starts at 160 °C. The production line is tailored for a polymer viscosity of 2×10^2 Pa×s running at 160 °C.

A) What would the processing temperature have to be for the novel polymer grade, in order to have viscosity in the range appropriate for the production line? **(3 points)**

B) How could the decomposition temperature of the polymer be altered (increased)? **(3 points)**

Q6)

A co-polymer of monomers n and m is prepared.



A) Explain how many 1H NMR peaks are generated by m and how these are split. **(4 points)**
B) Explain how many 1H NMR peaks are generated by n and how these are split. **(4 point)**
C) In the figure, a simplified 1H NMR spectrum of this copolymer is shown (without splits). Explain, based on shielding and deshielding, which protons belong to peaks A, B, C & D (consider overlap). **(6 points)**

IGNORE the protons of the OH groups on the ends of the molecule.

NMR Spectrum