Student Name: _____

CHEMICAL ENGINEERING 4X3/6X3

DAY CLASS
Duration 100 minutes **Dr. M. Thompson**
McMaster University Mid-Term **October 19, 2009**

This test includes 6 problems on 2 pages. This test paper **must be returned** with the answer booklet. You are responsible for ensuring that your copy of the paper is complete. Bring any discrepancy to the attention of your invigilator.

SPECIAL INSTRUCTIONS

1. McMaster standard calculator ONLY is permitted.
2. A one-sided 8 ½" x 11" cribsheet
3. Only solutions written in **PEN** will be re-marked if it is necessary
4. Marks for the problems are given (Total of 50 marks)
5. State clearly the units of any calculated value, marks will be removed if not stated.
6. Ensure name and ID number are included on all answer booklets.
7. Exam paper must be returned along with the answer booklet.

Question 1. (3 Marks)

Give a short answer (<7 words) to the following questions:

a) Name the term referring to the reason why a polymer under shear exhibits a melt temperature higher than its surroundings?
b) A polymer exhibits minimal chain motion below which transition, the glass transition or the crystal melting transition?
c) For two polymers with identical zero-shear viscosity but different polydispersity, which one will exhibit higher torque in an injection molding machine?

Question 2. (7 Marks)

Compute the number-average (M_n), weight-average (M_w) and polydispersity for a polymer given the following data:

Mol wt (g/mol)	1750597	660131	129927	25572	3636
Wt fraction	0.0005126	0.0025	0.00488	0.0022	0.000258

Question 3. (12 Marks)

A LDPE resin with the following expression for viscosity, $\eta = 1670e^{-0.04(T-320oC)}(\dot{\gamma}^{-0.4})$. The polymer has a melt density of 760 kg/m^3 at 290^{o}C is flowing through a rod die having a length of 35 cm and diameter of 1.6 mm. Determine the mass flow rate in kg/h and pressure drop in MPa, if it is known that the wall shear stress is 0.20 MPa.

Question 4. (13 Marks)

A HDPE resin was reported to have a melt index of 7 g/10min (otherwise known as 7 MI). The measurement was determined under the standard conditions recommended for this material according to ASTM D-1238 (capillary diameter 2.0955mm, capillary length 8.00mm, plunger diameter 9.5504mm, 2.16 kg load). Determine the melt viscosity of the polymer at this test condition. Melt density is 780 kg/m^3.

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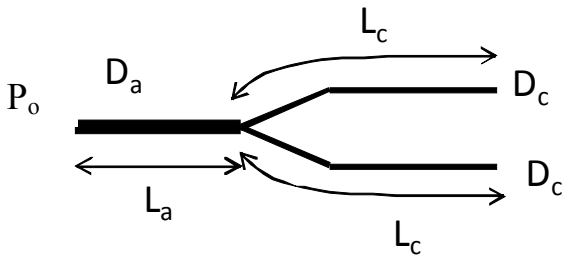
Question 5. (10 Marks)

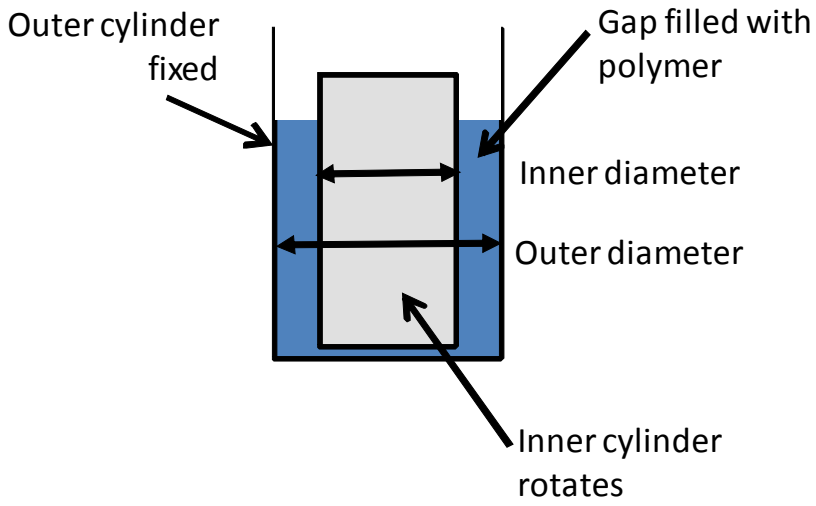
Polypropylene is being strand cut into pellets at the end of an extruder. The flow geometry inside the die is shown below with the main adapter pipe (A) being divided into two smaller capillaries (C). At 230°C, the melt density is 710 kg/m^3 and melt viscosity for the polymer is described by the following power law coefficients: m = 2833 Pa-s^n and n = 0.40. For a total production rate of 500 kg/h determine the diameter of each strand (D_c) [in units of mm] if the inlet pressure to Pipe-A at P_o is 14.26 MPa (gauge). The output pressure is atmospheric.



D_a = 4 mm
L_a = 35 mm
D_c = ?
L_c = 15 mm

Question 6. (5 Marks)

A concentric cylinder viscometer has a motor power of 1.3 KW which turns the inner cylinder while the outer cylinder surface remains fixed. Polymer sits in the gap between the two cylinder surfaces and is sheared. The outer diameter is 8 cm and the gap thickness is 5mm. The inner cylinder length is 9cm. For a polymer melt described by the following power-law expression: $\eta = 3410(\dot{\gamma}^{-0.55})$ determine the maximum speed the inner cylinder can rotate. Assume brake and hydraulic efficiencies of 100%. Answer must be stated in RPM (revolutions per minute) for full marks.



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