Name: _____

ID #: _____

University of Saskatchewan
Department of Mechanical Engineering
ME 478 – Introduction to Fire Protection Engineering

February 10, 2006	Mid Term Exam	90 minutes

100 Points Total

Closed Book Exam - students are permitted to bring one 8.5" x 11" sheet into the exam for formulae and other information; no formulae or other information may be brought into the exam in the memory of programmable calculators or any other electronic storage device

For numerical questions – please show all work in the space provided.
For descriptive questions – please answer each question in a concise and clear fashion in the space provided.

Question 1

a) With the 2005 editions of the National Building and Fire Codes, Canada introduced objective-based codes. Briefly describe how objective-based codes work, and how the new codes are different from the previous building and fire codes in Canada. (5 points)

b) Developed countries in Europe and Asia generally place more emphasis on public fire education and training than Canada. Why do you think that this is the case? (5 points)

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c) Briefly describe one method used to extinguish oil field fires in Kuwait at the end of the Gulf War in 1991. (5 points)

d) Briefly describe two methods used by engineers in the analysis of the collapse of the World Trade Center towers on September 11, 2001. (5 points)

e) Briefly discuss two reasons why fire protection engineering has not progressed at the same rate as other areas of engineering, such as structural engineering. (5 points)

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f) Identify three of the main fire test standard organizations. (5 points)

g) What is the most important quantity used to describe a fire? Name three fire tests that can be used to measure this quantity. (5 points)

h) Briefly explain the physical mechanisms involved in the burning of a candle. (5 points)

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Question 2

a) Calculate the equivalence ratio and adiabatic flame temperature at the lower flammability limit of methane in air. (10 points)

b) Briefly compare the chemical reactions used in ME 478 to describe combustion with actual combustion reactions. (5 points)

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Question 3

You are asked to investigate the expected fire behaviour of a material thought to have caused a fire.

a) Given the following data from a cone calorimeter test of a specimen of this material, calculate the heat release rate at time t_2, using the oxygen consumption calorimetry method. Consider both the concentrations of O_2 and CO_2 and assume that the product of density and heat of combustion is 17,200 kJ/m^3. (10 points)

Time	Volumetric Flow Rate (m^3/s)	CO_2 (by volume)	O_2 (by volume)
t_1	2.0	0.0%	20.95%
t_2	2.0	0.5%	20.7%
t_3	2.5	3.0%	17.0%

b) You are also asked to determine the concentration of gases in the combustion products when this material burns. The gas analyzer in the cone can be used to determine concentrations of oxygen, carbon dioxide and carbon monoxide. Identify one piece of equipment discussed in class that could be used to measure the concentration of other gases in the combustion products, and briefly describe how this equipment measures gas concentrations. (5 points)

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Question 4

A 4 mm thick piece of protective fabric, originally at room temperature (25ºC), is placed in a fire test furnace, where both sides of the fabric are subjected to a hot gas, which is at a temperature of 800ºC. The effective convective heat transfer coefficient for each side of the fabric, which includes the effects of both convection and radiation, is 100 $W/m^2 \cdot ºC$.

a) Estimate the surface temperature of the fabric after it has been in the test furnace for 20 s. (10 points)

b) The same fabric is placed in a test furnace until the temperature of the entire fabric has reached 700ºC. The fabric is then placed back in the room to cool. If the convective heat transfer coefficient on each side of the fabric is 3 $W/m^2 \cdot C$, estimate the length of time necessary to cool the fabric until its surface temperature is less than 50ºC. (5 points)

(properties of fabric: thermal conductivity = 0.08 $W/m \cdot ºC$, specific heat = 2000 $J/kg \cdot ºC$, density = 200 kg/m^3)

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Question 5

a) A person is standing 27 m away from the center of the base of the wall of an industrial building, which is on fire. This wall is 10 m high by 50 m wide and completely covered in flames, which project 2.0 m away from the wall. It can be assumed that the temperature of the flames on this wall is equal to 1000°C, and that the fire can be treated as a blackbody.

Assume that this person receives a second degree burn when the temperature of the surface of their skin increases from an initial temperature of 30°C to 60°C. The properties of skin are as follows.

thickness = 25 mm	density = 1000 kg/m3
specific heat = 3200 J/kg·°C	thermal conductivity = 0.8 W/m·°C

How long can this person stand in this particular location until they receive a second degree burn to any exposed skin? (10 points)

b) What is the name of the experiments that were used to develop the spatial separation requirements found in Canada's National Building Code? Who conducted these experiments? (5 points)

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