L4C1

THE INSTITUTION OF FIRE ENGINEERS
Founded 1918 • Incorporated 1924

IFE Level 4 Certificate in Fire Science and Fire Safety (HL)

Unit 1: Fire Engineering Science (Y/505/5931)

Thursday 16 March 2017

10.30 – 13.30

Instructions to Candidates

1. The time allowed for this examination is **THREE** hours.

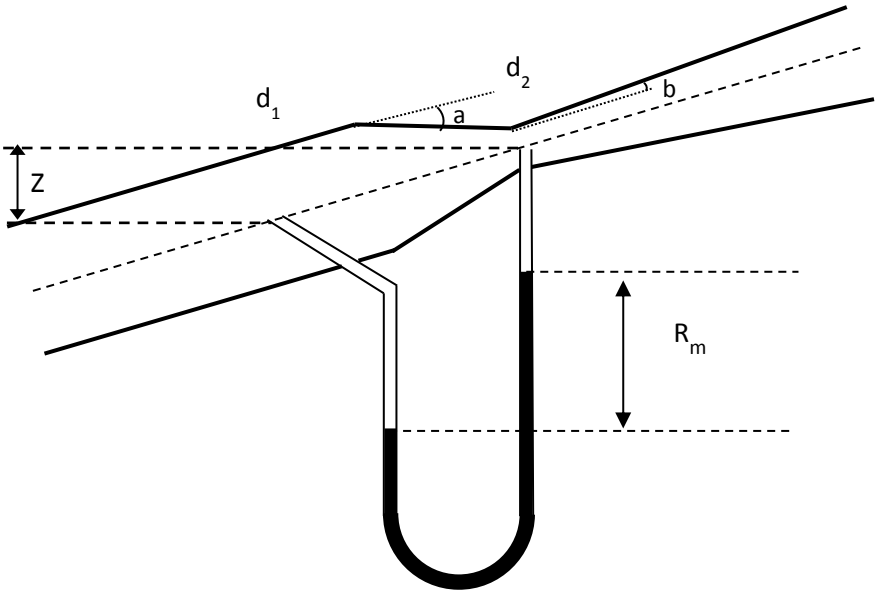
2. Candidates must answer **SIX** questions from the total of **EIGHT** questions set for this examination.

3. All questions carry equal marks and may be answered in any order. Candidates should follow the instructions provided in the question when composing their responses.

4. Candidates should record all of their answers in the answer book provided.

5. The question paper must be handed in with the answer book.

Question 1



a) Describe the operation of a Venturi meter. Include in your answer the significance of the angles “a” and “b” in the diagram above.

(6 marks)

b) The Venturi meter above has an entrance diameter of 30cm (d_1) and a throat diameter of 20cm (d_2). The height between d_1 and d_2 (Z) is 250mm. The Venturi meter is used in the process of evaluating the volume of gas flowing through a pipe. Note that the meter is positioned at an angle to the horizontal.

Use Bernoulli’s equation to calculate the actual volume of gas flowing when the pressure difference between the entrance and the throat is measured as 6cm on a water U-tube manometer. The discharge coefficient of the apparatus is 0.96 and the density of the gas in the pipe is $2kgm^{-3}$.

(14 marks)

Question 2

In order for a weir to function, it must create an energy change sufficient to make the flow pass through the critical point.

a) Explain the meaning of the term “critical point”. Include in your explanation the effect on depth of the liquid around the critical point.

(10 marks)

b) Explain why V notch weirs are used to measure small discharges in favour of rectangular weirs.

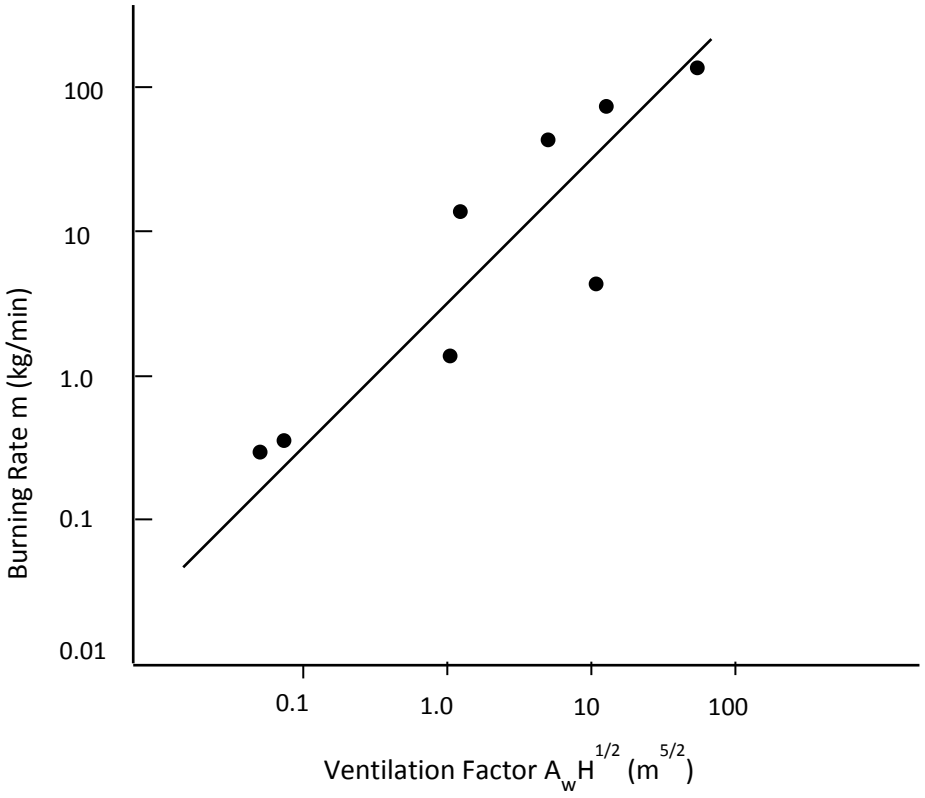
(4 marks)

c) Calculate the head of water needed above a V notch weir to produce a flow rate of 2.58×10^4 L/min if the notch angle is 80º and the discharge coefficient of the weir is 0.62 (correct to 2 decimal places).

(6 marks)

Question 3

The graph below shows the empirical relationship between the mass burning rate of cribs in a compartment and the ventilation factor of that compartment.



a) Use the line of best fit to approximate (to 1 decimal place) the equation that describes this relationship.

(3 marks)

b) What are A_w and H in the equation?

(2 marks)

c) Write the equation in SI units.

(2 marks)

d) The relationship above holds true whilst the fire is "ventilation controlled". Explain the meaning of the term "ventilation controlled" fire.

(4 marks)

e) Beyond an upper limit, the fire becomes independent of the ventilation factor and is mainly governed by two different factors. What are they and how do they affect mass burning rate?

(5 marks)

f) Explain in terms of energy why the heat released from a given mass of vehicle tyres is greater than that for the same mass of paper.

(4 marks)

[Please turn over]

Question 4

a) Use the example of rags soaked in linseed oil to explain spontaneous heating.

(5 marks)

b) Under what specific conditions will spontaneous ignition occur?

(6 marks)

c) The process of oxidation can be described in a number of ways. Consider the rusting of iron in the atmosphere to form iron (III) oxide. Write a balanced equation for this process and use it to give one definition of oxidation.

(5 marks)

d) Oxidation can occur without the need for elemental oxygen, for example magnesium will react with chlorine in an oxidation reaction to form magnesium ions and chlorine ions. Write a balanced equation that describes this process and use it to give an alternative explanation for oxidation.

(4 marks)

Question 5

a) Acetylene has the chemical formula C_2H_2. Draw its structure and use this to explain its reactivity.

(6 marks)

b) Explain why acetylene should not be stored where there are copper pipes in the vicinity.

(3 marks)

c) Like acetylene, benzene has the generic formula C_nH_n. In the case of benzene, n = 6. Draw the structure of benzene and use this to explain the characteristics of burning benzene.

(6 marks)

d) Benzene burns in oxygen to produce carbon dioxide and water. Use a balanced equation for this reaction to calculate how much oxygen is required for the complete combustion of 1 mol of benzene. (Atomic weights: oxygen = 16, hydrogen = 1, carbon = 12)

(5 marks)

Question 6

Dalton's Law of Partial Pressures states that the total pressure of a mixture of gases is given by $P_{tot} = P_1 + P_2 + \ldots P_n$.

A refrigeration sphere of diameter 180cm sits inside an insulated cone-shaped vessel of base diameter 350cm and height 300cm. The vessel contains 10kg of methane at 25^{o}C. A tube fitted with a one way valve feeds 25kg of oxygen at 12^{o}C into the vessel and the two gases mix.

a) Calculate the volume of the vessel.

(1 mark)

b) Calculate the partial pressures of each gas in the vessel.

(11 marks)

c) Use Dalton's Law of Partial Pressures to calculate the total pressure of the gas mixture within the vessel.

(2 marks)

d) If the refrigeration sphere cools the mixture at a rate of 1^{o}C every 45 seconds, calculate the temperature of the gas mixture after 9 minutes.

(6 marks)

All calculations correct to 2 decimal places

Gas constant = 8.31JK^{-1}mol^{-1}, Atomic weight oxygen = 16, Hydrogen = 1, Carbon = 12

Question 7

a) Describe electrical resistance.

(4 marks)

b) Explain four factors (other than potential difference) that affect the electrical resistance of a conductor in a circuit.

(12 marks)

c) Explain how two of the factors identified in response to part b) can contribute to the initiation of an electrical fire.

(4 marks)

[Please turn over]

Question 8

In an AC circuit, a 12 ohm resistor is connected in series with an inductance of 0.15H, across a 100 V_{rms}, 50Hz supply.

a) Calculate the total circuit impedance.

(4 marks)

b) Calculate the power factor of the circuit.

(2 marks)

c) Calculate the true power dissipated in the circuit.

(2 marks)

d) Sketch the impedance phase diagram for this circuit.

(3 marks)

e) If a capacitor is to be connected in parallel to reduce the power factor to as near unity as possible, calculate the theoretical value of the capacitor required. Express your answer in microfarads. Comment on the practicality of the value and the consequence of this.

(9 marks)