L4C1

THE INSTITUTION OF FIRE ENGINEERS
Founded 1918 • Incorporated 1924

IFE Level 4 Certificate in Fire Science and Fire Safety

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

Thursday 8 March 2018

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.

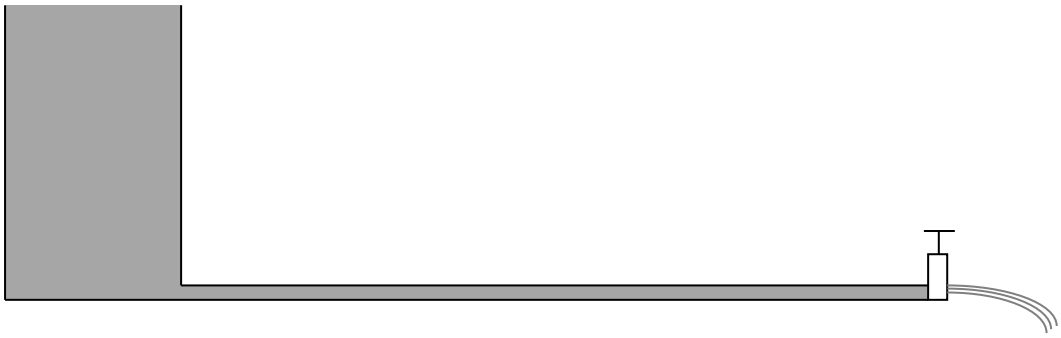
4. Candidates should record all of their answers in the answer book provided.

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

Question 1

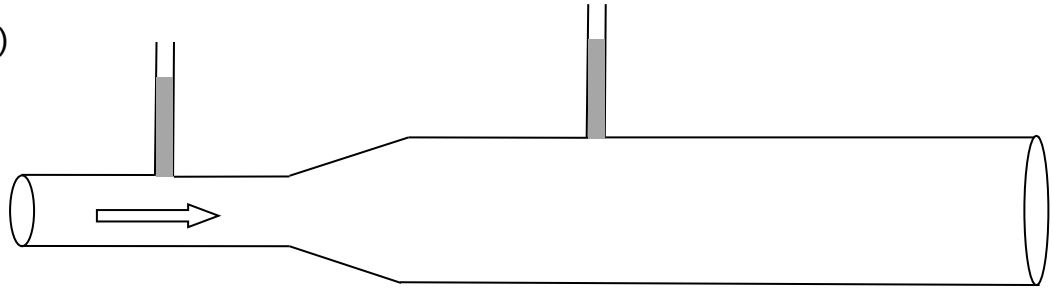
a) Explain the meaning of the term 'hydraulic gradient.' Explain how it is calculated.
(2 marks)

b) Copy the following two drawings below into your answer book and draw the hydraulic gradient <u>for each of the following four situations:</u>



i) Valve closed. (1 mark)
ii) Valve partly open. (1 mark)
iii) Valve fully open. (1 mark)

iv)



(1 mark)

c) An hydraulic pump operating at 120m above sea level is pumping fresh water along a line of 70mm hose to a branch with a nozzle diameter of 20mm. The hose passes over a hill with a maximum height of 300m above sea level, terminating at a branch pipe which is 136m above sea level. The pump is fed by a pressure fed supply nearby at a pressure of 2 bar and the *increase* in pressure due to the pump is *160%*. The pressure at the branch nozzle is 2.4 bar.

Use Bernoulli's equation to calculate the velocity and the flow at both the pump outlet and the branch nozzle.
(14 marks)

Question 2

TN-C, TN-S and TT are all types of earthing systems found in electricity supplies to consumers.

a) Explain why electrical installations are earthed.

(3 marks)

b) Describe how earthing is achieved in the TN-S system.

(3 marks)

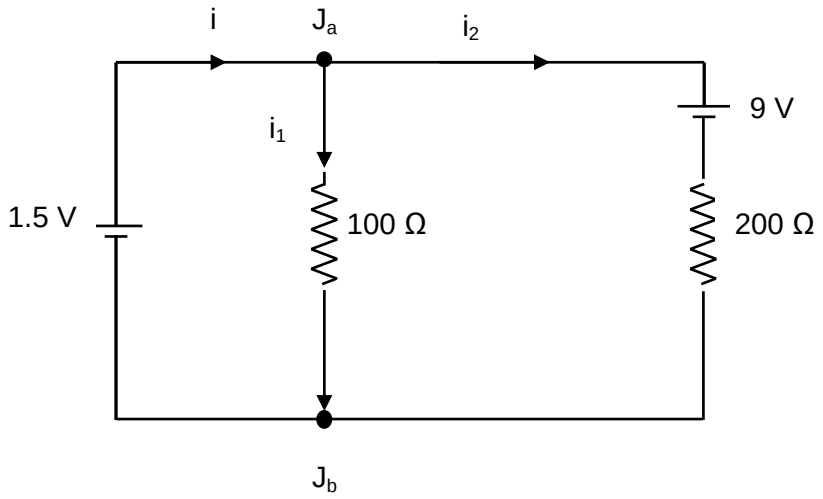
c) Referring to the TN-S system, draw a diagram in your answer book to show an earth fault loop and use it to explain the meaning of the external earth fault loop path for the system drawn.

(4 marks)

d) Explain how the earth fault loop impedance is used to calculate the correct type and rating of circuit protective device to protect the installation.

(4 marks)

e) Consider the d.c. circuit below:

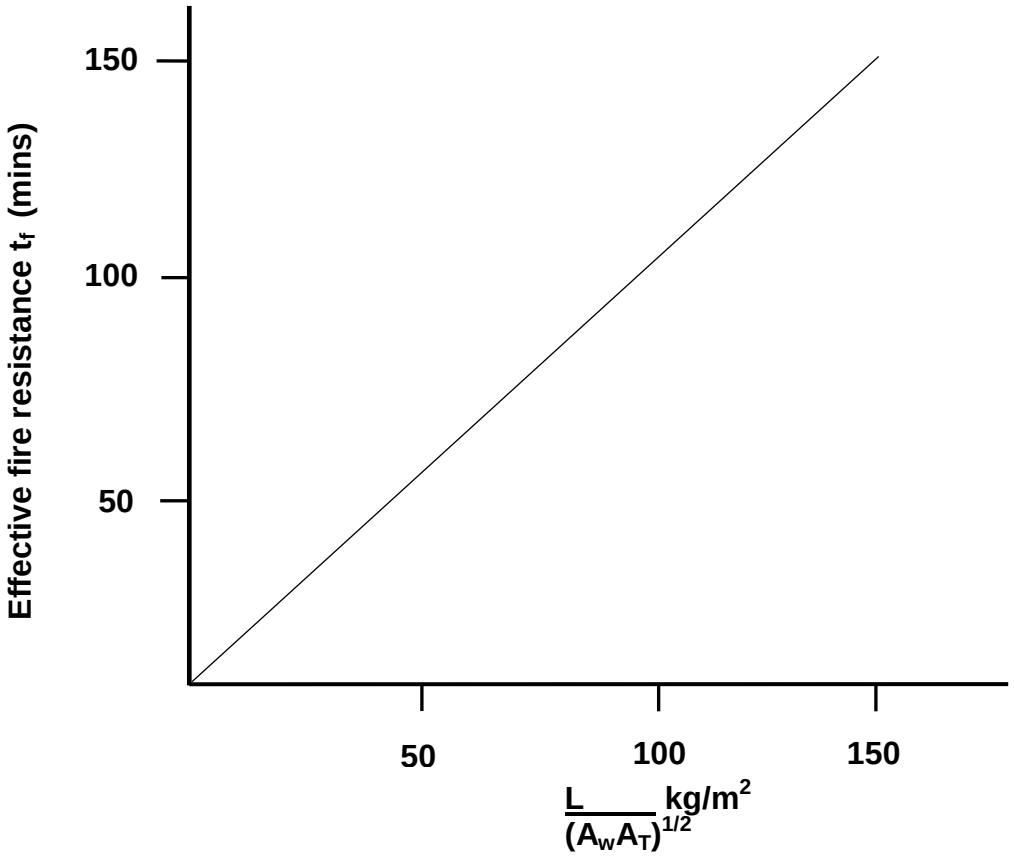


Use the arbitrarily decided directions of i, i_1 and i_2 to treat the circuit as 2 loops joined at junctions J_a and J_b. Now use Kirchoff's laws to find the values of the currents i, i_1 and i_2.

(6 marks)

[Please turn over]

Question 3



a) The graph above has become known as Law's Correlation (Law's Law). Referring to the graph, write an equation that describes this relationship. (2 marks)

b) What are the factors t_f, L, A_w and A_T? (4 marks)

c) Describe what the graph is showing and how it could be used practically. (5 marks)

d) One factor is missing from the relationship. What is this factor and why does its omission not affect the result? (2 marks)

e) One factor has not been taken into account in the fire tests used by Law to show this relationship. What is that factor and how does it affect the results? (5 marks)

f) Explain how this relationship has been used practically. (2 marks)

Question 4

A cylindrical vessel, 36cm diameter and 75cm in height contains ethylene glycol solution ($C_2H_6O_2$). The liquid enters at a temperature of 12^{o}C via an inlet valve situated near to the top of the vessel and the valve remains open until the vessel is $^2/_3$ full. The solution is then heated by an element powered by 240V a.c. supply which has a phase angle between voltage and current of 20^o. The heating element has a resistance of 100Ω. Once the temperature of the liquid reaches 34^{o}C a valve opens at an outlet near to the base of the vessel and it is pumped out via an opening of 8cm diameter at a velocity of 0.04m/s. Once all the liquid has been pumped out, the outlet valve closes and the inlet valve opens to replenish the liquid.

(Specific heat capacity of ethylene glycol is 2.36 kJ/kgK, density = 1100 kgm^{-3})

a) Calculate the mass of the liquid in the vessel when the inlet valves closes.

(4 marks)

b) If the RMS (average) values for the current and voltage for this circuit are 14A and 170V respectively, calculate the average power delivered to the heater.

(2 marks)

c) The units for specific heat capacity of a material are J/kgK ($\frac{J}{kg\ K}$).

Use this, your answers and the information above, to calculate the amount of time taken for the outlet valve to operate.

(5 marks)

d) How long after the outlet valve opens does the inlet valve open?

(6 marks)

e) State the assumptions that you have made in your calculations above.

(3 marks)

[Please turn over]

Question 5

a) Various medical, industrial and research processes utilise ionising radiation sources in their processes. Give two examples of premises where ionising radiation sources are used. Describe how they are used and the hazards associated with their use.

(6 marks)

b) Describe the physiological effects of ionising radiation on the human body. Describe how the risk can be minimised.

(6 marks)

c) Thorium 230 has a half life, $t_{1/2,}$ of 8×10^4 years. Sketch a graph in your answer book using four calculated data points of how the isotope decays over time. Label the axes and title the graph.

(8 marks)

Question 6

a) Consider the combustion of candle wax in air. Why does the inclusion of a wick allow sustained and stable combustion whereas igniting a candle without a wick is difficult?

(4 marks)

b) What is the definition of Flash Point of a flammable liquid?

(2 marks)

c) The amount of flammable vapour given off from a liquid, and therefore the extent of the ignitable flammable vapour mixture with air, is dependent on a number of factors. Describe four of these factors.

(8 marks)

d) Describe what is meant by the term Upper Explosive Limit (UEL) for a flammable liquid.

(2 marks)

e) Explain why the term Upper Explosive Limit and Upper Flammable Limit are frequently (and not inaccurately) interchanged.

(4 marks)

Question 7

a) Define an Ideal Gas and explain the relationship between its pressure, temperature and volume.

(4 marks)

b) Does the gas in a cylinder of liquefied petroleum gas behave as an ideal gas? Explain the reason for your answer.

(8 marks)

c) The cylinder of a compressed air breathing apparatus has a volume of 9 litres. For an average consumption of 40 litres per minute, calculate the pressure at which the warning whistle must be set so that it sounds when the remaining air will last 10 minutes. Explain fully any assumptions made.

(8 marks)

Question 8

Provide a scientific explanation of how the effects of heat will alter the structure and strength of the following materials when used in construction.

a) Timber

(5 marks)

b) Glass

(5 marks)

c) Reinforced concrete

(5 marks)

d) Metals

(5 marks)
