# IFE Level 4 Certificate in Fire Safety and Fire Science

## Unit 1 – Fire Engineering Science

### Examiner Report – March 2018

**Introduction**

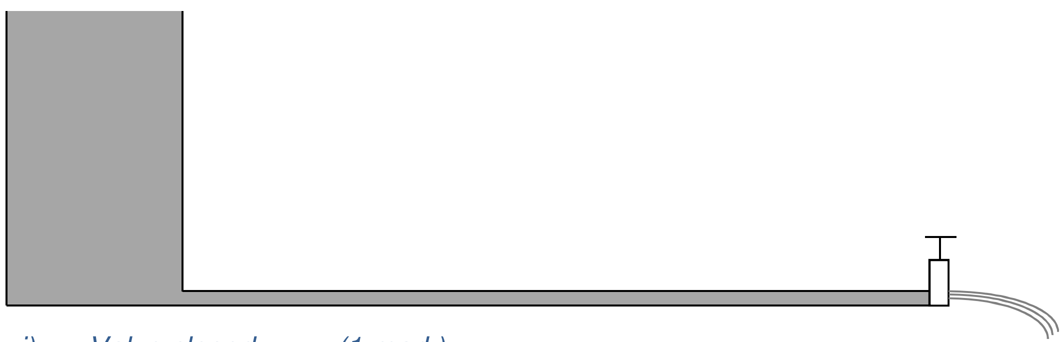
Candidates performed better than in 2017 and 36% of candidates were successful in achieving a pass. It appeared that many of these candidates had prepared well for the examination

Candidates performed best on questions 3, 5 and 8. They performed least well on questions 7 and 1.

**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 for each of the following four situations:*

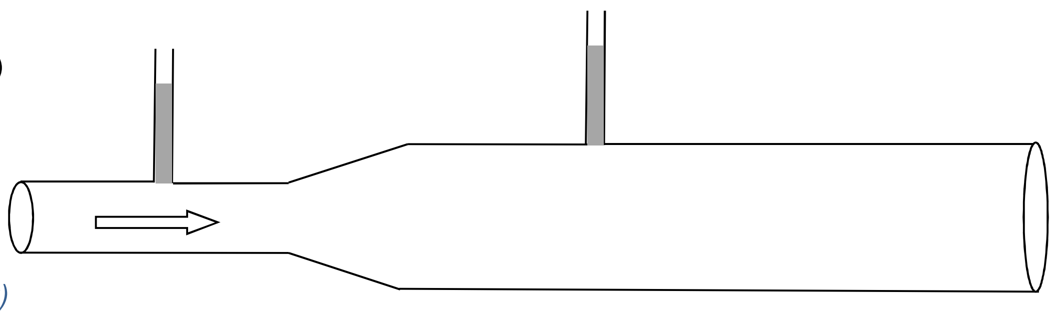


*i) Valve closed. (1 mark)*

*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)*

**Examiner Feedback**

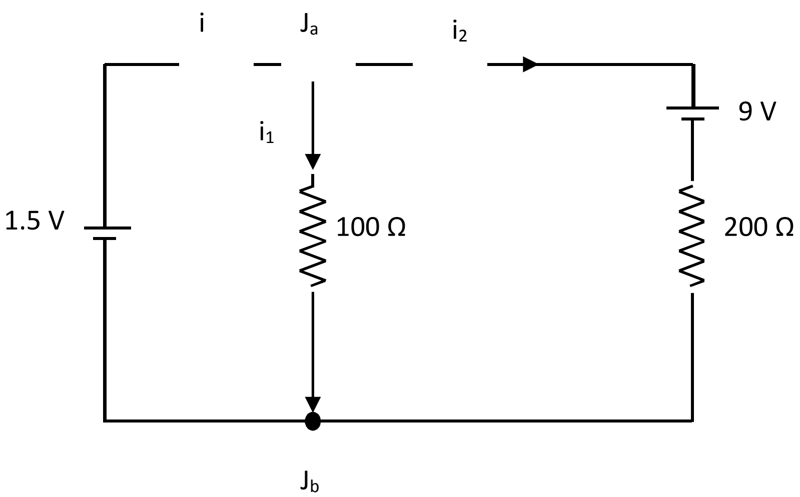
Few candidates understood the concept of "hydraulic gradient". Many candidates appeared to believe that this involved the angle of a pipe whereas in reality it is a vector value representing changed pressure over distance.

The Bernoulli problem was straightforward but this element of the question was also answered poorly. Few candidates provided fully correct responses. Many candidates omitted key elements from their calculations.

## 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:*



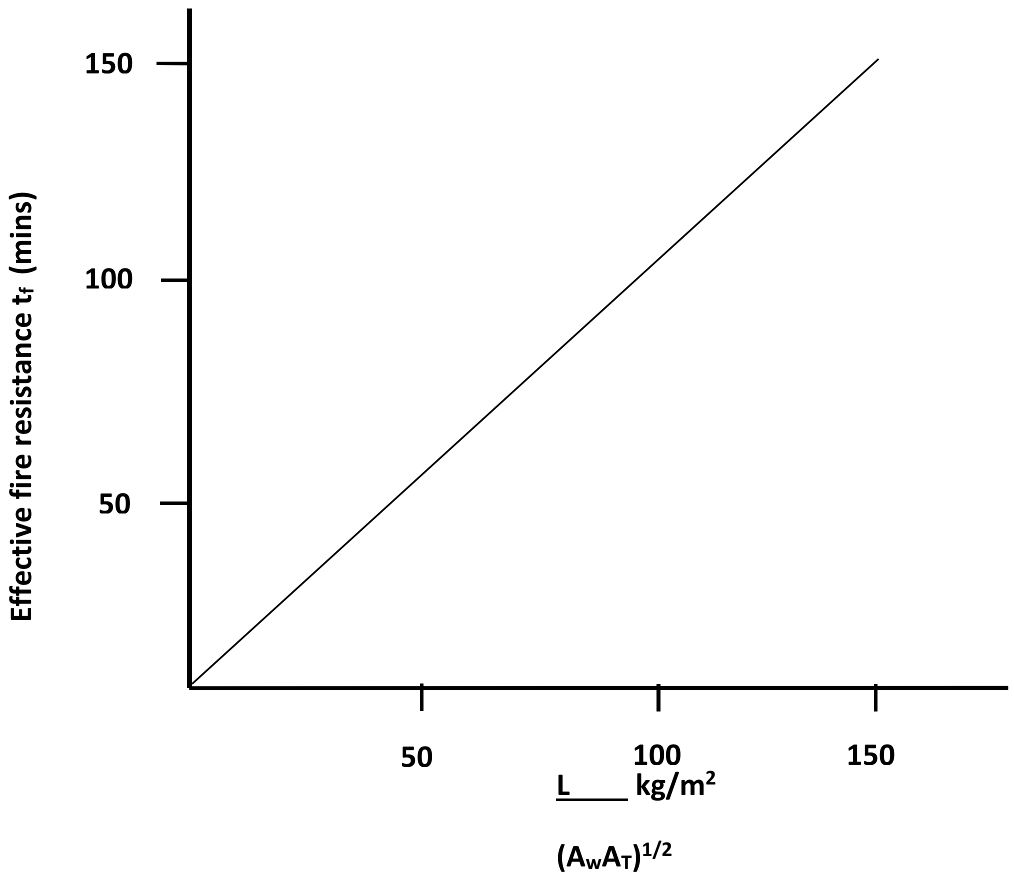

*Use the arbitrarily decided ...ions of $i$, $i_1$ and $i_2$ to treat the circuit as 2 loops joined at junctions $J_a$ and $J_b$. Now use Kirchoff's laws to find the values of the currents $i$, $i_1$ and $i$ (6 marks)*

**Examiner Feedback**

The first part of this question required an understanding of earth fault loop impedance. Candidates were asked to draw a diagram representing this. Few candidates achieved good marks for these parts of the question.

The problem involving Kirchoff''s Laws was also answered poorly with many candidates using Ohm's Law as the basis of their calculations. Candidates should be aware that Ohm's Law is not appropriate for use when dealing with any circuit involving two or more battery cells.

## 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)*

**Examiner Feedback**

This was a popular question and was generally answered well. However, candidates were often unfamiliar with the way in which Law's Law relates to fire intensity.

In responding to part e) candidates often failed to realise that the factor that has not been taken into account is the thermal mass or thermal inertia of the compartment boundaries in the test; the amount of heat flux from the materials that constitute these boundaries will have a significant effect on the intensity of the fire because radiation is the most significant factor. Candidates should be aware that prior to Law's Correlation fire testing of materials had relied on the standard time-temperature fire curve. Law's correlation does take account of fire severity and this is now taken into account when testing materials.

## 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°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°. The heating element has a resistance of 100Ω. Once the temperature of the liquid reaches 34°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)*

**Examiner Feedback**

This question was the least popular option for candidates. Candidates who broke the problem down into stages were generally able to attain high marks.

## 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 $8 \times 10^4$ 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)*

**Examiner Feedback**

In response to part a), most candidates limited their responses to medical uses in X-rays and radiotherapy. Few candidates explored industrial usage. In responding to part b), candidates generally referred to time, distance and shielding for precautionary measures; few candidates considered other issues such as labelling, training, transport and storage.

In responding to part c), few candidates demonstrated understanding of the term half-life.

**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)*

**Examiner Feedback**

The terms “flashpoint” and “upper explosive limit” were well understood and most candidates gained marks for the definitions provided. Candidates were generally on less secure ground when providing in-depth descriptions in response to part c) and explanations in response to part e).

Part e) was often answered poorly. Candidates should be aware that an explosive atmosphere does not always result in an explosion but if flame propagation travels in a confined space, where the speed of travel is so great that the increase in pressure is not able to dissipate quickly enough, there will be an over pressure which can be classed as an explosion so the terms are interchangeable because they define the same thing other than the fact that an explosion requires a build-up of pressure.

**<u>Question 7</u>**

*a) Define an Ideal Gas and explain the relationship between its pressure, temperature and volume. (4 mark)*

*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)*

**Examiner Feedback**

This question was a popular choice for candidates but few candidates attained more than one or two marks for their responses. Few candidates demonstrated understanding of an ideal gas. Candidates were also unable to explain the assumptions that underpin the calculation required by part c).

**<u>Question 8</u>**

*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)*

**Examiner Feedback**

This was a popular question but few candidates gave a true scientific explanation of the effects of heat on common building materials. Candidates often presented only general information about how fire affects the materials. An example of a full response in the context of metals is as follows:

Metals are good conductors of heat because the electrons are free to move throughout the metal, so they may transmit this to remote areas of structure not directly in contact with fire. Metals will expand considerably when heated and if joists are built into the wall they may push outward causing collapse and/or transmission of fire through openings. Metals will lose their load bearing strength when heated - they are malleable because the layers of atoms can slide over each other and this effect is increased with any increase in energy via heat to the atoms.