# IFE Level 3 Diploma in Fire Science and Fire Safety

# Unit 1 – Fire Engineering Science (Version 1)

## Examiner Report – March 2020

### Introduction

Candidates performed well with 66% of those who sat the examination achieving a pass.

Candidates generally performed best on questions 5 and 8 with the average mark attained for each of these questions being 12. Candidates performed least well on question 7 where the average mark attained was 5.

### Question 1

*a)*

*i) With regards to electricity flowing in a circuit, define the following terms and state the units of each:*

- *current*
- *voltage* *(4 marks)*

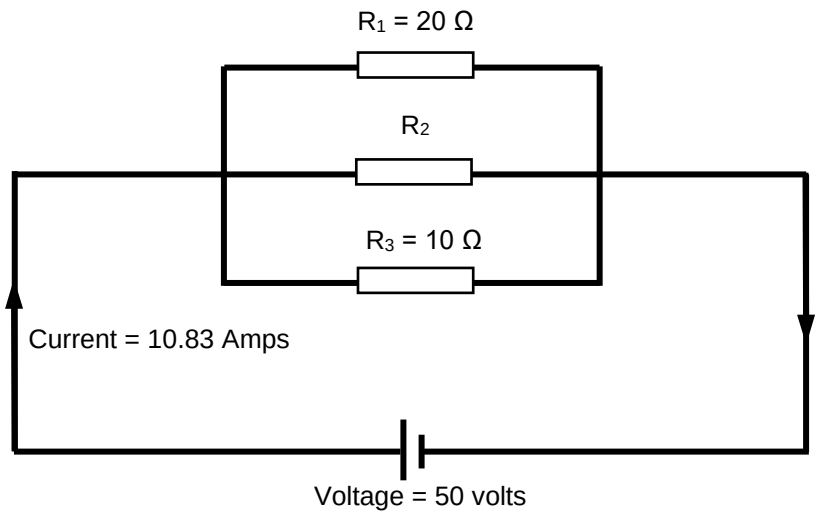
*ii) Explain the relationship between voltage and current in a circuit.* *(2 marks)*

*b) A High Rupture Capacity (HRC) fuse may be used in an electrical circuit.*

*i) Explain the function and operation of an HRC fuse.* *(4 marks)*

*ii) Sketch a diagram of an HRC fuse and label the main component parts.* *(4 marks)*

c) *Consider the following circuit.*



*i) Calculate the value of resistor $R_2$.*
*(2 marks)*

*ii) Calculate the total resistance in the circuit. Ignore the resistance of the cables.*
*(2 marks)*

*iii) Calculate the total power being drawn from the supply. (2 marks)*

**Examiner Feedback**

Candidates generally performed well on part a) with most candidates being able to provide correct definitions of the items identified in the question.

Part b) was less well answered with most candidates appearing to be unfamiliar with High Rupture Capacity (HRC) fuses. Candidates should be aware that HRC fuses are overcurrent circuit protection devices, used to protect a circuit from damage caused by excess current or short circuit faults. They are 'single use' devices which, once blown, cannot be repaired and reused. They are extremely reliable and robust, with highly predictable performance characteristics and are designed to withstand the high pressures developed under short circuit conditions.

Part c) should have been straightforward for candidates but was often answered poorly. The answer to part i) was $R_2 = 15.05\ \Omega$, the answer to part ii) was $4.62\ \Omega$ and the answer to part iii) was $P = 10.83 \times 50 = 541.5$ watts

## Question 2

*a) With reference to the SI system:*

*i) explain what is meant by the term "base units". (2 marks)*
*ii) identify any three base units. (3 marks)*
*iii) explain the term "derived units". (2 marks)*

*b) Explain the following terms:*

*i) elastic deformation (2 marks)*
*ii) plastic deformation (2 marks)*
*iii) yield point (2 marks)*

*c) Young's modulus for a given steel is 196GPa. Calculate the extension of a steel wire 4.5 m long with a cross-sectional area 1.0 x $10^{-3}$ $cm^2$ when the wire is stretched by a load of 0.8 kg. (Take g to equal 9.81 $m/s^2$) (7 marks)*

**Examiner Feedback**

Part a) was usually answered well with most candidates familiar with the definitions. However, candidates were less familiar with the terms presented in part b) and this part of the question was less well answered.

Few candidates provided the correct answer in response to part c) as most were unable to convert the value to base units and apply the formula correctly. The correct answer could have been presented as either 0.0018 *m or* = 1.8 *mm*

## Question 3

*a) Explain the principle and components of the fire tetrahedron. (5 marks)*

*b) Explain the difference between flaming and smouldering combustion. (6 marks)*

*c) Name and give the simple chemical formulae for the first three members of the alkane group and describe the trend in their relative melting points, boiling points and densities. (9 marks)*

**Examiner Feedback**

There were many good responses to this question with the average mark attained by candidates being 9.

Part a) was generally answered well.

Part b) was less well answered with few candidates able to demonstrate sufficient detailed understanding to score more than a few of the marks available.

In responding to part c), most candidates were able to name the three compounds ie Methane, Ethane and Propane and give the correct chemical formula for each one but few could explain the underpinning trends in melting points, boiling points and densities.

## Question 4

*a) A firefighting jet of water is flowing from a 25mm nozzle on a branch at the end of a line of 70mm delivery hose. The water pressure at the nozzle is 4 bar. If the water stream is projected vertically, calculate the maximum height at which an effective firefighting stream could be expected. Use the following formula for your calculation:*

$$H_e = \frac{2}{3}\left(H - 0.113\frac{H^2}{d}\right)$$ *Where* $H = 10P$ *(which is the max theoretical height without practical losses) (4 marks)*

*b) Calculate the maximum height that any droplets of water from the jet in part a) might reach and explain why this is greater than the height of the effective firefighting stream. (6 marks)*

*c) As water flows through a line of hose, frictional losses will cause a reduction in pressure. List five factors that describe how energy is lost due to friction. (5 marks)*

*d) If the flow of water through the nozzle in part a) above is 650 litres per minute, and the line of hose feeding it comprises 7 x 25 metre lengths (friction factor 0.005 per length), calculate the pressure at the pump. Assume that there is no difference in height between the pump and the branch. (5 marks)*

**Examiner Feedback**

Part a) was generally answered well. However, many candidates made careless errors with the calculations which meant that they were unable to attain full marks. The answer required was 21.84 metres.

Part b) was poorly answered. However, the calculation required only an adjustment of the formula used in part a). Candidates should be aware that above 21.84 metres the water stream will start to break-up and would no longer form an effective jet for firefighting. Practical testing has shown that the maximum effective jet will be two-thirds of the height of the highest droplets of water from the jet.

Part c) was straightforward and was often answered well with most candidates familiar with the factors affecting energy loss due to friction.

Part d) was often poorly answered as many mistakes were made in the arithmetic. The correct answer was 5.98 bar (or 6 bar)

**Question 5**

*a) Explain what is meant by the term coefficient of superficial expansion for a particular material. State the formula for finding this coefficient and explain the terms. (3 marks)*

*b) Describe Boyle's Law. State the formula and explain the terms. (3 marks)*

*c) Describe three methods by which heat can transfer from one place to another. (9 marks)*

*d) A pressurised aerosol can is at a pressure of 3 bar and a temperature of 20°C. If the can explodes in a fire when it reaches a temperature of 1,150°C, what would be the pressure in the can at the point of explosion? Assume that the volume of the can remains constant when heated. Show all formulae and calculations used. (5 marks)*

**Examiner Feedback**

Part a) was often answered poorly. However, there were many good responses to part b).

Candidates generally appeared familiar with the methods of heat transfer and many candidates were able to achieve most, if not all, of the marks available for part c) of the question.

Few candidates were able to carry out the calculation required by part d). There were many errors in the approach taken and few candidates recognised the need to convert the temperature to Kelvin. The correct answer was 14.6 bar.

## Question 6

*a) Materials can respond in three ways to radiant energy. Describe these possible responses. (6 marks)*

*b) Briefly describe the difference between non-ionising and ionising radiation and identify one type of non-ionising radiation and one type of ionising radiation. (4 marks)*

*c) Define the following terms:*

*i) half-life (2 marks)*

*ii) radioactive decay (2 marks)*

*iii) isotope (2 marks)*

*d) Briefly describe the two different categories of damage ionising radiation can cause to biological cells. (4 marks)*

**Examiner Feedback**

In responding to part a), few candidates appeared to understand the concepts of transmission, absorption and radiation.

Part b) was poorly answered. This question required knowledge of the emitted energy from each of radiation and the resulting damage caused.

Part c) was generally answered well with most candidates familiar with the definitions required.

In responding to part d), few candidates understood the difference between deterministic and stochastic effects of radiation and the damage that they can cause.

## Question 7

*a) Describe the properties and hazards of carbon monoxide. (6 marks)*

*b) Write a balanced chemical equation for the incomplete combustion of methane. (4 marks)*

*c) The production of carbon monoxide is one physical characteristic of combustion that provides an operating principle for detectors. Another characteristic is flame. Describe the forms of radiant energy in a flame and explain how they are detected to produce a fire alarm. (10 marks)*

**Examiner Feedback**

This question was the least popular option for candidates and those candidates that did attempt the question often secured only low marks.

When responding to part a), candidates were usually able to present one or two properties of carbon monoxide but comprehensive responses scoring high marks were rare. Candidates should be aware that carbon monoxide is:

- a colourless, odourless, tasteless, gas
- produced by incomplete burning of carbon-based fuels
- a strong reducing agent
- slightly less dense than air (The difference is so slight that CO is found to evenly distribute itself indoors.)
- poisonous at very low concentrations
- attracted to haemoglobin over 200 times more strongly than oxygen. The presence of carbon monoxide prevents some of the haemoglobin found in red blood cells from carrying sufficient oxygen

Part b) was poorly answered as few candidates were able to provide a balanced chemical equation.

Part c) was also poorly answered with many candidates unable to name infrared, ultra violet, visible light and heat as forms of radiant energy or to describe detectors.

**Question 8**

*a) With regards to fire pumps, define the following terms:*

*i) pump* *(2 marks)*
*ii) water power* *(2 marks)*
*iii) brake power* *(2 marks)*
*iv) pump efficiency* *(2 marks)*

*b) A pump discharges 2000 litres of water per minute at 6 bar pressure.*

*i) Calculate the water power of the pump.* *(3 marks)*
*ii) If the pump is 70% efficient, calculate the brake power of the engine driving the pump.* *(4 marks)*
iii) *If the design of the pump were to be improved so that the discharge increased to 2400 litres of water per minute at 6 bar, calculate the new efficiency of the pump.* *(3 marks)*

*c) Explain why a pump could never be 100% efficient in practice.* *(2 marks)*

**Examiner Feedback**

This question was a popular option for candidates and it was often answered well.

Most candidates were able to provide good definitions for the items required by part a) and many scored good marks.

The calculations required by part b) were often completed correctly and again candidates often achieved a high proportion of the marks available.

Few candidates answered part c) well.  However, only two points were required to secure the marks eg friction losses and leakages.

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