# IFE Level 3 Diploma in Fire Science and Fire Safety

# Unit 1 – Fire Engineering Science (Version 2)

## Examiner Report – March 2020

### Introduction

36% of the candidates that sat the examination attained a pass.

There were few high scores with only three candidates attaining either a B or A grade.

Candidates generally performed best on questions 2, 4 and 5. However, the average mark achieved for each of these questions was only 7.

Candidates generally performed least well on questions 1 and 7.

### Question 1

*a) With the aid of a diagram, identify the components of a single phase double wound transformer. (6 marks)*

*b) Explain the purpose and operating principle of an isolating transformer. (4 marks)*

*c) A transformer with an output of 12 volts and 0.48 amps is supplying a lamp using a 37.5m, 1mm$^2$ aluminium two-core cable. Calculate the resistance of the lamp.*
*Note: the resistivity of aluminium is 28 μΩmm. (10 marks)*

#### Examiner Feedback

This question was the least popular option for candidates and those candidates that did attempt the question often attained only low scores. It was common for candidates to omit part c) completely; however, this part of the question carried half of the marks available so therefore candidates who did not answer it lost the opportunity to score any of these marks.

Part a) was often answered well.

Unfortunately, part b) was less well answered. Few candidates referred to safety and many provided detailed descriptions of step-up/step down transponders which did not answer the question. Candidates should be aware that:

- the main purpose of the isolation transformer is safety
- it protects electronic components in sensitive equipment and persons from electrical shock.
- it physically separates the power from the primary and secondary sides
- isolation transformers may be step down but often have a 1:1 ratio, ie do not change the output voltage.

Where candidates attempted part c), many failed to double the cable length. Full marks for part c) were awarded where candidates correctly identified that $R_L = 22.9\ ohms$.

## Question 2

*a) Describe:*

*i) Newton's First Law (Law of Inertia)* *(2 marks)*
*ii) the difference between scalar and vector measures* *(2 marks)*

*b) Explain the following terms:*

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

*c) Describe Hooke's Law.* *(3 marks)*

*d) Young's modulus for a given steel is 196GPa. Calculate the extension of a steel wire 2.8 m long with a cross-sectional area 1.0 x $10^{-3}$ $cm^2$ when the wire is stretched by a load of 0.5 kg. (Take g to equal 10)* *(7 marks)*

**Examiner Feedback**

Part a) was usually answered well.

Part b) was less well answered with some candidates considering that "yield point" meant breaking point. Candidates should be aware that yield point is the point when elastic deformation changes to plastic deformation ie when stress is first increased the deformation will be elastic but as the stress increases a point is reached where the deformation changes from elastic to plastic deformation and the point at which this occurs is the yield point.

Part c) was usually answered well.

Part d) sometimes caused problems as candidates appeared to struggle when managing calculations involving large power numbers. The correct answer to the problem was 0.71mm.

## 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**

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. Some candidates presented answers based on the difference being ventilation; this did not score marks as the processes are different from controlled ventilation.

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) Define the following terms:*

*i) half life (2 marks)*
*ii) radioactive decay (2 marks)*
*iii) isotope (2 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) Describe gamma decay and explain how gamma decay differs from alpha and beta decay. Include a comparison of the differing ionising potential and penetrating powers in your response. (10 marks)*

**Examiner Feedback**

Part a) was often answered well although some candidates made errors in responding to part a)i). Candidates should be aware that half life is the time it takes for the radioactivity to fall by half.

In responding to part b), it was common for candidates to provide lists of examples of the different types of radiation without actually describing basic differences as required by the question.

Part c) was often answered poorly with candidates providing insufficient detail to secure high marks. Some candidates incorrectly gave high ionising potential to gamma decay compared to alpha and beta.

## Question 5

*a) Calculate the pump pressure required to supply a branch delivering 400 litres/minute at 4 bars pressure operating at a height of 27 metres above the pump outlet and located at the end of 6 x 25 metre lengths of 45mm hose (friction factor 0.005). Show all formulae and calculations. (6 marks)*

*b) Explain, including a description of the physical laws involved, all the factors contributing to the required pump pressure calculated in part a) above. (11 marks)*

*c) Comment upon the results of the calculation from part a) above, identifying any practical problems and suggesting solutions. (3 marks)*

**Examiner Feedback**

There were many good responses to part a) although some candidates omitted steps in the calculation. The correct answer was 12.55 bar.

In responding to part b), many candidates identified at least some of the factors. Friction loss appeared to be well understood. It was common for candidates to miss out gravity in their considerations.

In responding to part c), candidates often identified that a pump pressure of 12.55 bars is excessive and exceeds the recommended working and test pressure for hose. (Working pressure 7 bars) and that the practical solution is to increase the hose diameter. Keeping the pressure at the pump to 7 bars maximum will slightly reduce the flow with larger diameter hose. To maintain the flow a second branch or twinning of hose, will be required.

**Question 6**

*a) Explain the difference between the thermal capacity of a substance and its specific heat capacity. State the units for each. (9 marks)*

*b) Define the term latent heat of vaporisation and state the units. (3 marks)*

*c) Define the term phase change (phase transition). (3 marks)*

*d) How much heat energy is required to convert 2·5 kg of ice at -2°C to water at 0°C? (SHC of water is 2108 J $kg^{-1}$ $K^{-1}$. Specific latent heat of fusion of water is 3.34x$10^5$ J $kg^{-1}$) Show all formulae and calculations used. (5 marks)*

**Examiner Feedback**

In responding to part a), candidates were often more familiar with specific heat capacity than with thermal capacity. Many candidates did not provide correct units for either.

Part b) was usually answered well although, again, units did not appear to be well known.

Parts c) and d) were generally answered well.

## 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 not answered well and the average mark attained was 5.

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. Candidates often quoted $CO_2$ instead of CO.

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) Describe the three primary sub-atomic particles that make up an atom. (5 marks)*

*b) Describe the relationship between the number of electrons in an atom and valency. (5 marks)*

*c)*

*i) Identify the chemical structure of organic peroxides. (4 marks)*

*ii) Describe the particular hazards of these materials. (6 marks)*

**Examiner Feedback**

Part a) was usually answered well. However, answers to part b) often lacked sufficient precision to score more than one or two marks.

Part c) was not answered well with many candidates showing limited understanding of peroxides. In responding to part c)ii), a surprising number of candidates omitted to consider the fact that peroxides and hydroperoxides are powerful oxidising agents.

Date issued: September 2020