IFE Level 3 Diploma in Fire Safety and Fire Science

Unit 1 - Fire Engineering Science

Examiner Report – March 2015

Introduction

Candidates performed less well than in previous years with only 30% of candidates achieving a Pass compared to 55% achieving a Pass in 2014.

The examination questions tested topics from across the syllabus, including some topics that had not been tested in the last few years. The most popular question, and the one on which many candidates achieved their highest mark, was question 10. There were many examples of candidates achieving a high score for question 10 but not achieving comparatively high marks on other questions.

As in previous examinations, many candidates failed to follow the instructions in the question and did not "describe" or "explain" as the questions required. Candidates are advised to follow the instructions in the question and to note the marks available. There were many examples of candidates providing two-line answers in response to questions that required an "explanation" and had 10 marks allocated to them; conversely, there were numerous examples of candidates providing several pages of irrelevant information where only two marks were available.

Question 1

a) Explain the following terms:
- *i. Elastic deformation (2 marks)*
- *ii. Plastic deformation (2 marks)*
- *iii. Yield point (2 marks)*

b) State the following equations, including the relevant units in the answer:
- *i. The equation for determining stress in a material (2 marks)*
- *ii. The equation for determining strain in a material (2 marks)*

c) Describe the relationship between stress and strain during elastic deformation to determine Young's modulus. (4 marks)

d) A brass wire is 2.5 metres (m) long and has a cross-sectional area 1.0 x 10^{-3} square centimetres (cm^2). The wire is stretched 1.0 millimetre (mm) by a load of 0.4 kilograms (kg). Calculate Young's modulus for brass. (Take the force of gravity (g) to equal 10.) (6 marks)

Examiner feedback

This was not a popular choice of question for candidates. Those candidates who did attempt the question generally performed poorly.

Few candidates were able to define the terms in part a). Some candidates made the mistake of assuming that the terms related to plastics and went on to give answers describing the effects of

heat on plastics. Candidates who made this mistake often carried the mistake through to their answers to other parts of the question and therefore scored few, if any, marks.

Candidates who achieved marks for this question often achieved them for parts b) and c) which were the best answered parts of the question.

Question 2

a) Describe the thermal expansion of liquids. Include an annotated formula for this expansion in your answer. (10 marks)

b)

i. With reference to tank fire fighting, explain the term "boilover" (4 marks)
ii. What three conditions must exist simultaneously for a boilover to occur? (3 marks)
iii. What can be done to prevent a boilover? (3 marks)

Examiner feedback

This question required candidates to demonstrate an understanding of the process of expansion in liquids. In response to part a), few candidates understood that only cubical expansion can occur. Thermal expansion is not the boiling of a liquid and discussions of this process gained no marks.

In the second part of the question, candidates often described BLEVE or slopover rather than "boilover" and therefore gained no marks. Candidates should be aware that boilovers require specific conditions. The three conditions are:

- water must be present
- the oil must produce a heat wave
- the oil must be viscous enough to form a froth when the heat wave hits the water and turns it into steam**.**

In response to part b)iii), the candidate wrote about actions to tackle boilovers instead of writing about actions to *prevent* them which was required by the question.

Question 3

a) Flame is one physical characteristic of combustion that provides an operating principle for fire detectors. State two other characteristics. (2 marks)
b) State the forms of radiant energy emitted by a flame and explain which are suitable for use in fire detectors. (6 marks)
c) Draw and label a schematic diagram of the components of an infra-red flame detector. (6 marks)
d) Describe where flame detectors have, or may have, an advantage over point detectors and for what type of fire risk they are normally used. (6 marks)

Examiner feedback

Part a) was often answered well and candidates achieved both marks.

In part b), heat was often identified incorrectly as a form of radiant energy. The forms of radiant energy are visible light, infra-red radiation and ultra-violet radiation.

Some good diagrams were provided in response to part c) although some candidates drew smoke detectors or beam detectors rather than an infra-red flame detector as required by the question.

The response to part d) was often incomplete as many candidates did not follow the instructions fully; some candidates omitted to make the comparison to point detectors and others omitted to identify the relevant type of fire risks.

Question 4

a) Describe the process of combustion and distinguish between flaming and smouldering combustion. (8 marks)
b) Describe briefly, with chemical equations, three types of combustion which do not involve oxygen from the air. (12 marks)

Examiner feedback

This was not a popular question and those candidates that did answer this question often provided incomplete responses.

Candidates who understood that flaming combustion needed vapour and that smouldering involved the surface of the fuel gained good marks in part a). Oxygen can be contained within the reacting chemicals to support combustion or other elements as oxidising agents. Many candidates mistakenly described the mechanism of ventilation controlled fires and not the surface reaction for smouldering fires.

In response to part b), few candidates were able to identify three types of combustion that do not involve oxygen from the air. Three types of combustion that were expected were:

- The combustion may take place using oxygen which is contained within the burning material, the combustible material and the supporter of combustion being together in the same compound.
- Oxygen may be provided by one of the materials in a mixture of compounds.
- Elements other than oxygen may be considered as oxidising agents; examples of these are: chlorine and fluorine. "Combustion" may occur with these substances; for example, hydrogen will burn explosively with chlorine.

Question 5

With reference to radioactivity:
a) Define the following terms:
i. Nuclear radiation (2 marks)
ii. Decay (2 marks)
iii. Half-life (2 marks)
b) Explain the construction and properties of alpha and beta particles and gamma radiation, including their penetrating powers. (9 marks)
c) Describe the biological effects of radiation. (5 marks)

Examiner feedback

There were many good responses to this question on radiation with parts a) and b) being particularly well answered.

Part c) was the least well answered part of the question with candidates not considering the issue from all angles; even good answers often failed to describe the immediate effects of radiation exposure at high dose levels and some responses cited only Cancer as a biological effect.

Question 6

a) Define and explain the terms "friction" and "velocity". (6 marks)

b) An object with a mass of 15 kilograms (kg) is sitting at rest on a rough surface with a coefficient of friction of 0.7. A force of 150 Newtons (N) is then applied to start the object moving. Complete the following calculations, showing all formulae used.

i. Calculate the frictional force against motion caused by the rough surface. (3 marks)
ii. Calculate the acceleration of the object along this rough surface. (3 marks)
iii. If the object starts from rest, how long will it take to reach a velocity of 25 metres per second (m/s)? (3 marks)
iv. What distance will it have travelled and at what speed will it be travelling after 1 minute? (5 marks)

Examiner feedback

Friction and velocity were often described well in response to part a). Many candidates also knew the formula required and followed the logical progression of part b).

Some candidates mistakenly assumed that speed and velocity are synonymous. Some candidates did not attempt the calculations in part b) at all and other made mistakes or appeared to guess at figures.

Question 7

a) Briefly describe an electric battery. (5 marks)
b) Explain the term "oxidation-reduction reaction" with regards to an electric cell. (4 marks)
c) Explain the difference between a primary and a secondary battery (5 marks)
d) Describe the hazards and risks of lead-acid batteries and describe the precautions that should be taken when fighting fires involving lead-acid batteries. (6 marks)

Examiner feedback

A battery is stored chemical energy converted into electrical energy. Candidates who stated this often carried on to achieve good marks. There were five marks available for part a) but many candidates did not provide full descriptions and this limited the number of marks that could be achieved.

In part b), electron transfer is the reduction-oxidation reaction which is most significant to an electric cell. Again, candidates did not always provide full information so limited the number of marks achieved

There were many errors in response to part c). Explanations of the difference should have included the following points:

- Primary batteries irreversibly transform chemical energy to electrical energy. When the supply of reactants is exhausted, energy cannot be readily restored to the battery.
- Secondary batteries can be recharged; that is, they can have their chemical reactions reversed by supplying electrical energy to the cell, approximately restoring their original composition.

Part d) was often omitted; where it was answered, responses were generally poor with few candidates recognising that hydrogen is released during recharging or that the products of combustion (if batteries are involved in fire) will be corrosive and poisonous.

Question 8

a) Define "organic chemistry" and describe its two classes. (8 marks)
b) Briefly explain in terms of chemical bonding the difference between saturated and unsaturated organic compounds. (6 marks)
c) Name the first member of each group of compounds (saturated and unsaturated) and state its chemical formula. (6 marks)

Examiner feedback

This was not a popular option for candidates.

Good responses to part a) identified aliphatic and aromatic and provided full descriptions. In part b), good responses described the carbon bonding characteristics of saturated and unsaturated compounds identifying Alkanes, Alkenes and Alkynes. Less successful responses failed to mention aromatic compounds and triple bonded alkynes.

In response to part c), the names of the first group members were often incorrect.

Question 9

a)
i. Define the term "absolute zero". (2 marks)
ii. Describe an absolute temperature scale and the SI unit of temperature.(8 marks)
b) Briefly describe the principles of heat transfer between two materials. (4 marks)
c) Describe the three things on which the rise in temperature of a body depends when heat is added. (6 marks)

Examiner feedback

Absolute zero is defined in terms of energy and candidates who started with this in their response to part a) scored well. Responses to part b) usually recognised that the SI unit is Kelvin and the scale begins at absolute zero. However, descriptions often lacked detail so few candidates achieved high marks for this element of the question.

In response to part b), some candidates gave long descriptions of methods of heat transfer rather than focussing on a brief description of the principles (ie heat flows from the hotter to the cooler etc) as required by the question.

In response to part c) candidates did not always identify the three things correctly (ie the amount of heat energy supplied to the body, the mass of the body and the specific heat capacity of the body); in addition, descriptions were often omitted which meant that candidates were not able to achieve the additional marks available for demonstrating full understanding.

Question 10

a) $L = \frac{2}{3} d^2 \sqrt{p}$ is the formula for nozzle discharge. Annotate this formula. (2 marks)

b) Using the graph paper provided, construct a graph to illustrate this formula for values of p between 4 and 10 when d = 12.5 (14 marks)

c) Clearly mark on your graph the value of:

i. the discharge when the pressure is 15

ii. the pressure when the discharge is 265 (4 marks)

Examiner feedback

The majority of candidates provided good responses to this question and many candidates secured full marks.

In response to part a), some candidates failed to provide full annotations; for example they identified that "L" represents litres but omitted to explain that this is the flow rate in litres per minute.

In response to part b), marks were sometimes lost for plotting only a straight line from the points and for failing to label axes.