L3D1

THE INSTITUTION OF FIRE ENGINEERS
Founded 1918 • Incorporated 1924

IFE Level 3 Diploma in Fire Science and Fire Safety (VRQ)

Unit 1: Fire Engineering Science (A/505/6005)

Friday 13 March 2015

10:15 – 13:15

Instructions to Candidates

1. The time allowed for this examination is **THREE** hours.

2. Candidates are to answer **SIX** questions from the total of **TEN** 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 answers.

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.

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 1.0×10^{-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)

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)

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)

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)

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)

[Please turn over]

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)

_____

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)

_____

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)

_____

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)

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)

Please write your candidate number clearly on the graph paper and place the graph paper in your answer book.