IFE Level 4 Certificate in Fire Safety and Fire Science

Unit 1 – Fire Engineering Science

Examiner Report – March 2016

Introduction

Standards were in line with previous years with 28% of candidates achieving a Pass.

There was a wide divergence in standards with some candidates achieving very high marks on one or more questions (several candidates achieved 20 marks on at least one question) and others achieving very low marks on all questions.

Candidates generally performed best on questions 3 and 7 and least well on question 2.

Question 1

a) Using the energy equation and an annotated diagram, explain the operating principle of a Pitot Tube. (10 marks)

b) A Pitot Tube fitted to the nose of an aircraft flying at an altitude of 4000m indicates a static pressure of $6.6x10^4$ Pa. Calculate the velocity of the aircraft. Take the density of air at 4000m to be $0.8kgm^{-3}$ and the pressure of the air at 4000m as $6.2x10^4$ Pa. (10 marks)

Examiner Feedback

Some candidates performed well on this question and 14 candidates achieved between 16 and 20 of the marks available.

Candidates who performed well on part a) of the question showed that a pitot tube contains a stagnation point at which the fluid has a velocity of zero. However, some candidates relied upon a diagram showing one tube inside another and omitted the significance of the zero velocity at stagnation point.

In the calculation in part b), some candidates failed to realise that the aircraft was in level flight and therefore the equation can be simplified by applying 0 to the term Z.

Question 2

A cylindrical steel tank 300cm in diameter and 600cm in height stands on a lattice support such that its base is 125cm from the ground. The tank is completely filled with Sodium Hydroxide solution. The tank contents are leaking from a 15cm diameter hole, the centre of which is 200cm from the top of the tank. (Density of NaOH solution is given as 1.4g/ml)

a) Calculate, to three decimal places, the mass of liquid in the tank before any leakage. Show all calculations. (3 marks)

b) Calculate, to three decimal places, the velocity of the liquid as it begins to escape the tank. Show all calculations. (10 marks)
c) What would be the velocity of the liquid if the hole were 100cm in diameter? Give your answer to three decimal places. Compare this value with that in b) and briefly explain the difference. Show all calculations. (5 marks)
d) How would the velocity change if the tank was positioned on the floor instead of on a stand 125cm off the ground? Briefly explain your answer. (2 marks)

Examiner Feedback

This question was a popular option for candidates but few candidates achieved high marks. Those candidates that attained good marks, converted the given data to SI units recognising that 100cm = 1m and not 1000. They recognised that in applying Bernoulli's equation several factors could be ignored (height off the floor) and others contribute to the outcome (depth of liquid above hole).

Candidates that did not achieve high marks either failed to recognise the data was not in SI units or failed to correctly convert cm into m and g/ml into kg/m^3. Some candidates did not appreciate which of the values given would affect the velocity of the liquid, particularly considering height off the floor as a significant factor when it is not.

Question 3

a) Describe five factors that affect the rate of combustion of timber. (5 marks)
b) What does activation energy mean? How does it affect the flammability of a substance? (3 marks)
c) Describe how free radicals are formed in combustion with particular reference to homolytic cleaving and show how their production is part of a chain reaction. (6 marks)
d) Chain reactions involving free radicals can usually be divided into three distinct processes. Describe each of the three processes. (6 marks)

Examiner Feedback

There were some excellent responses to this question with several candidates achieving full marks for their response and many others achieving between 12 and 19 marks.

Candidates who attained high marks provided a scientific explanation of activation energy as a threshold of energy to be overcome before a chemical reaction can take place. They demonstrated understanding of the unique arrangement of sharing electrons in the covalent bond that makes radicals so reactive and fully explained initiation, propogation and termination

Candidates that performed poorly on the question often provided a non-specific explanation of activation energy such as "the energy required to activate combustion" and/or provided a description of free radicals merely as reactive elements responsible for the combustion process.

Question 4

a) Write a balanced equation that describes the combustion of ethane in air. (5 marks)
b) ΔH_c is the term given for the heat of combustion for a substance. For ethane, these values are:

Liquid - ΔH_c (ethane) = -1599 KJ Mol^{-1}
Vapour - ΔH_c (ethane) = -1423 KJMol^{-1}

Explain why two different values are given. (4 marks)

c) *The values for ΔH_c (ethane) are arrived at using a Bomb Calorimeter. Give three reasons why the results obtained from such a device are reliable and repeatable. (3 marks)*

ΔH_c can be calculated if the heat of formation (ΔH_f) is known for both the products and the reactants using the formula: $\Delta H_c = \Sigma \Delta H_f$ (products) - $\Sigma \Delta H_f$ (reactants)

d) *Use your balanced equation from part a) and the data below to calculate a value for ΔH_f for oxygen. Explain the value arrived at.*
ΔH_f (ethane) = -83.7 KJMol^{-1}
ΔH_f (carbon dioxide) = -392.6 KJMol^{-1}
ΔH_f (water) = -240.5 KJMol^{-1} (vapour) (8 marks)

Examiner Feedback

This question was not a popular option for candidates.

The majority of candidates that did attempt the question attained 5 marks or fewer for their response.

Those candidates that attained high marks, provided a balanced equation for the combustion of ethane in air and were then able to use this when following the instructions in part d). The majority of candidates failed to show that the chemical formula for ethane is C_2H_6 and/or were unable to correctly balance the equation. Even with an unbalanced equation, candidates could have gained 8 marks for following instructions in part d) if they knew ethane to be C_2H_6.

Question 5

a) *The terms used to classify chemicals for international transportation have recently been standardised to the UN Globally Harmonized (UNGH) System. Under this system, explain how flammable liquids are defined and how they are divided into categories. (8 marks)*

b) *Published standards and guides give recommendations and guidance for the control of fire and explosion risks on sites at which chemicals are stored or processed in significant quantities. When selecting a site on which to erect a petro-chemical installation, describe the factors that should be considered in order to control the risk of fire and explosion. (12 marks)*

Examiner Feedback

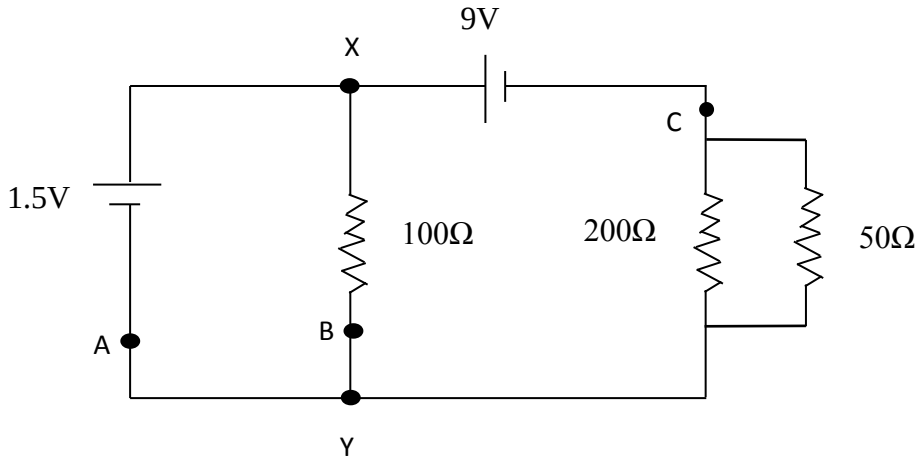
Few candidates achieved high marks for their response to this question.

Many candidates did not appear to be familiar with the new categories and quoted old categories. In addition, many candidates did not appear to understand the factors to be considered to control the risk of fire and explosion in the given context and provided general comments related only to issues such as water supplies. The factors that could have been described included: sufficient area to provide safe segregation of different types of

chemicals; sufficient clear space from boundaries, plant buildings and other combustible storage that might create a fire exposure hazard; no gradient variants likely to cause hazards; means to control the flow of potential spillages to limit environmental damage; no overhead power cables; means to prevent unauthorised access.

Question 6

Consider the electrical circuit below. (Note that this circuit has two loops that are connected at junctions X and Y and each loop contains a cell and resistor/s.)



a) *Identify and state the rule that governs the value of current flowing in and out of junctions within an electric circuit. (3 marks)*
b) *Identify and state the law that governs the changes in potential difference around a loop circuit such as above. (3 marks)*
c) *Use these two rules to calculate the value of the current at each of the points A, B and C. Show all calculations. (14 marks)*

Examiner Feedback

The complex circuit required an application of Kirchoff's first and second laws. Candidates who attained high marks considered the circuit as two loops as directed in the text of the question and then applied Kirchoff's rules to successfully solve the problem.

Less successful candidates described Ohms Law to explain the voltage and current distribution within the complex circuit and then attempted to use it to solve the calculation instead of taking note as directed that this was a circuit made from two loops containing two cells.

Question 7

a) *Explain the following terms that relate to protective devices in electric circuits.*
   i. Operating Current
   ii. Fusing Factor
   iii. Breaking Capacity
   iv. Short Circuit Current (8 marks)

b) Compare the semi-enclosed re-wireable fuse with the H.B.C (high breaking capacity) fuse. Your answer should include advantages and disadvantages for each device. (12 marks)

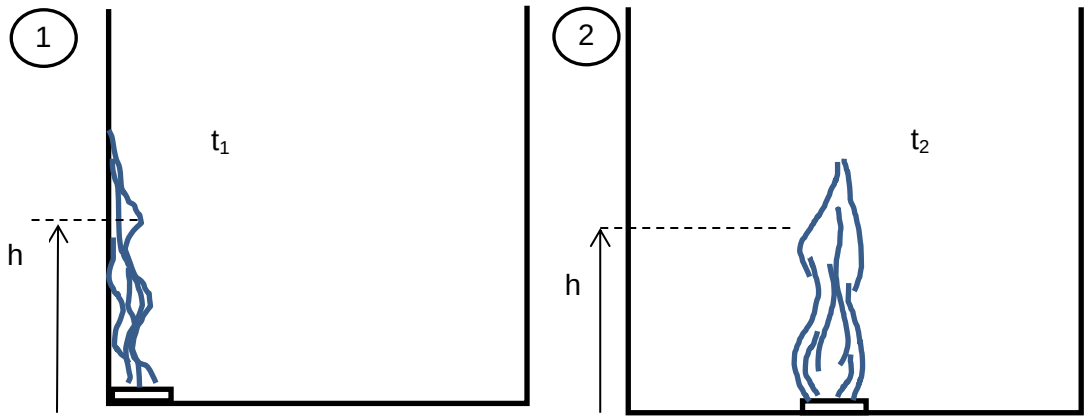
Examiner Feedback

Many candidates performed well on this question and one candidate attained full marks. Some candidates confused one term with another and/or provided imprecise language in describing the terms. Some candidates also confused HBC, and re-wirable fuses with cartridge fuses and miniature circuit breakers.

Question 8

a) Orientation is one factor that affects the rate of spread of flame in solids. Identify and explain six additional factors. (18 marks)

b) Consider the two situations in the diagram below. They each show the free burning of identical materials in identical rooms. Situation 1 shows burning against a non-combustible wall; situation 2 shows the fire is in the centre of the room. There is no limit to the amount of oxygen available for combustion. Compare the temperatures t_1 and t_2 of the flame taken at the same height h and at the same time in the fire's development in each case. Explain your answer. (2 marks)



Fire plume against a wall

Fire plume in centre of room

Examiner Feedback

This question was a popular choice for candidates and many candidates achieved marks of 8 or above for their response. Candidates who achieved good marks recognised that a fire in the centre of a room will be cooled by being surrounded by air, whereas a fire against a wall will "hunt" for oxygen and only be cooled by air on part of its perimeter.

Some candidates failed to describe the factors affecting rate of spread of flame or merely listed them without explanation. A common error was the failure to understand that a fire against a wall is not cooled by that wall but rather the fire will reach higher and burn hotter than a fire in the centre of a room.