Questions

1 How many significant figures are in 0.0200 g?

A. 1
B. 2
C. 3
D. 5

2 A burette reading is recorded as 27.70 ± 0.05 cm^3. Which of the following could be the actual value?

I. 27.68 cm^3
II. 27.78 cm^3
III. 27.74 cm^3
A. I and II only
B. I and III only
C. II and III only
D. I, II, and III [1]

IB May 2011

3 A piece of metallic aluminium with a mass of 10.044 g was found to have a volume of 3.70 cm^3.

A student carried out the following calculation to determine the density:

$$\text{density (g cm}^{-3}) = \frac{10.044}{3.70}$$

What is the best value the student could report for the density of aluminium?

A. 2.715 g cm^{-3}
B. 2.7 g cm^{-3}
C. 2.71 g cm^{-3}
D. 2.7146 g cm^{-3} [1]

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4 Which experimental procedure is most likely to lead to a large systematic error?

A. Determining the concentration of an alkali by titration with a burette
B. Measuring the volume of a solution using a volumetric pipette
C. Determining the enthalpy change of neutralization in a beaker
D. Measuring the volume of a gas produced with a gas syringe [1]

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5 Which are likely to be reduced when an experiment is repeated a number of times?

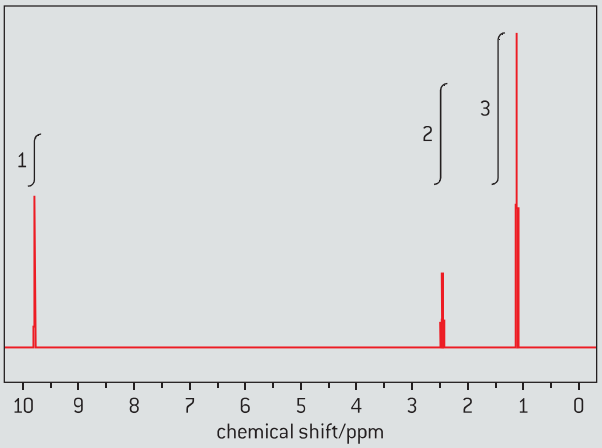
A. Random errors
B. Systematic errors
C. Both random and systematic errors
D. Neither random nor systematic errors [1]

IB November 2009

6 Deduce the IHD for codeine using section 37 of the *Data booklet*.

7 Deduce the IHD for a molecule of molecular formula $C_5H_{10}N_2$.

8 The ^1H NMR spectrum of **X** with molecular formula C_3H_6O is shown below.



Source: SDBSWeb, http://sdbs.riodb.aist.go.jp (National Institute of Advanced Industrial Science and Technology)

a) Deduce which of the following compounds is **X** and explain your answer. [2]

$CH_3-CO-CH_3$; CH_3-CH_2-CHO;

$CH_2=CH-CH_2OH$

b) Deduce which one of the signals in the ^1H NMR spectrum of **X** would also occur in the spectrum of one of the other isomers, giving your reasoning. [2]

c) The infrared and mass spectra for **X** were also recorded.

(i) Apart from absorptions due to C−C and C−H bonds, suggest **one** absorption, in wavenumbers, that would be present in the infrared spectrum. [1]

(ii) Apart from absorptions due to C−C and C−H bonds, suggest **one** absorption, in wavenumbers, absent in this infrared spectrum, but present in one of the other compounds shown in part **a)**. [1]

d) Suggest the formulas and m/z values of **two** species that would be detected in the mass spectrum. [2]

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Topic 11 – Measurement and data processing

End of topic questions (page 289)

1. C; note that each trailing zero is also counted as a significant figure;

2. A; answer II is incorrect, as $27.78 > 27.70 + 0.05 = 27.75$

3. C; the least precise value (3.70 cm^3) has three SF, so the answer should also be rounded to three SF;

4. C; a typical laboratory beaker has no thermal insulation; the error will be caused by the loss of heat to the environment;

5. A; in contrast to systematic errors, random errors tend to cancel one another when the experiment is repeated several times;

6. the molecular formula of codeine is $C_{18}H_{21}N_1O_3$, so $IHD = 18 - 0.5 \times 21 + 0.5 \times 1 + 1 = 9$; the same result can be obtained by counting rings and π-bonds: there are five rings, one double C=C bond, and one aromatic system of six π-electrons (equivalent to three π-bonds), so $IHD = 5 + 1 + 3 = 9$

7. $IHD = 5 - 0.5 \times 10 + 0.5 \times 2 + 1 = 2$

8. **a)** $CH_3{-}CH_2{-}CHO$; the spectrum shows three different chemical environments of H atoms, so it cannot be $CH_3{-}CO{-}CH_3$ (it has only one chemical environment of H atoms) or $CH_2{=}CH{-}CH_2OH$ (it has four chemical environment of H atoms); also, the integration ratio of signals is 3 : 2 : 1, which is true only for $CH_3{-}CH_2{-}CHO$; finally, the signal in the 9.4–10 ppm region can belong only to the CHO group (all other signals will appear below 7 ppm);

b) this question is somewhat incorrect, as no two signals in these compounds will have *exactly* the same chemical shift and shape; however, the signal of the CH_3 group in $CH_3{-}CO{-}CH_3$ will have approximately the same chemical shift (2.2–2.7 ppm) as the signal of the CH_2 group in $CH_3{-}CH_2{-}CHO$ (2.5 ppm), as both groups are adjacent to a carbonyl group;

c) **i)** 1700–1750 cm^{-1} due to the aldehyde group (CHO);

ii) 1620–1680 cm^{-1} due to the C=C bond in $CH_2{=}CH{-}CH_2OH$ and 3200–3600 cm^{-1} due to the hydrogen bonding in alcohols (O–H bond in the same compound);

d) $C_3H_6O^{\bullet+}$ with $\frac{m}{z} = 58$ (molecular ion), CHO^+ with $\frac{m}{z} = 29$ (loss of C_2H_5 group), $C_2H_5O^+$ with $\frac{m}{z} = 29$ (loss of CHO group), CH_3^+ with $\frac{m}{z} = 15$ (loss of CH_2CHO fragment).