Neap

Trial Examination 2021

Suggested solutions

QCE Chemistry Units 1&2

Paper 2

SECTION 1

QUESTION 1 (11 marks)

a) m(ethanol) = initial burner mass – final burned mass = 120.04 – 119.61 = 0.43 g *[1 mark]*

$n(\text{ethanol}) = \dfrac{\text{mass ethanol}}{\text{molar mass}} = \dfrac{0.43}{46.08} = 0.00933$ *[1 mark]*

ΔT = final temperature – initial temperature = 32.5 – 22.0 = 10.5 *[1 mark]*

$Q = mc\Delta T = 175 \times 4.18 \times 10.5 = 7.68$ kJ *[1 mark]*

$\text{MHC} = \dfrac{Q}{\text{moles of fuel}} = \dfrac{7.68}{0.00933} = 823 \text{ kJ mol}^{-1}$ *[1 mark]*

b) Add absolute uncertainty in measurements when subtracting values:

absolute uncertainty in m(ethanol) = 0.02; absolute uncertainty in ΔT = 1 *[1 mark]*

Convert to relative uncertainties:

relative uncertainty in m(ethanol) $= \dfrac{0.02}{0.43} \times 100 = 4.7\%$;

relative uncertainty in $\Delta T = \dfrac{1}{10.5} \times 100 = 9.5\%$;

relative uncertainty in $m = \dfrac{2}{175} \times 100 = 1.1\%$. *[1 mark]*

Add relative uncertainties as values were multiplied and divided to calculate MHC:

total relative uncertainty = 4.7 + 9.5 + 1.1 = 15.3% *[1 mark]*

Convert relative uncertainty to absolute value from the MHC:

absolute uncertainty $= 15.3\% \times 823 = 126$ kJ *[1 mark]*

c) The experimental value is lower than expected, thus we are looking for sources of heat/energy loss.

- heat loss to air/heat absorbed by can *[1 mark]*
- incomplete combustion *[1 mark]*

QUESTION 2 (9 marks)

a) Trichloromethane has dipole forces (and dispersion forces). *[1 mark]*

Carbon dioxide has dispersion forces only. *[1 mark]*

The stationary phase/silica gel is polar and has hydrogen bonding/dipole forces. *[1 mark]*

Trichloromethane will strongly adsorb to the silica gel, unlike the non-polar carbon dioxide. *[1 mark]*

Therefore carbon dioxide will leave the column first. *[1 mark]*

b) Correct measurements deduced from diagram *[1 mark]*

$R_f(\text{solvent 1}) = \frac{28}{43} = 0.65$ *[1 mark]*

$R_f(\text{solvent 2}) = \frac{11}{54} = 0.20$ *[1 mark]*

Histidine is the compound that best matches these values. *[1 mark]*

QUESTION 3 (9 marks)

a) Decreasing the temperature lowers the kinetic energy of the reactants. *[1 mark]*

This results in fewer collisions where the combined kinetic energy is greater than the activation energy, *[1 mark]*
thus slowing the rate of reaction *[1 mark]*
and increasing the time taken to produce enough sulfur/precipitate to block the cross. *[1 mark]*

Note: The reverse is acceptable, where increasing the temperature increases the kinetic energy and rate of reaction, if this is fully explained.

b) $n(Na_2S_2O_3) = 0.005 \times 0.30 = 0.0015$; $n(HCl) = 0.004 \times 0.70 = 0.0028$ *[1 mark]*

$n(\text{HCl needed}) = 0.0015 \times 2 = 0.0030$, thus HCl is limiting. *[1 mark]*

$n(\text{S formed}) = 0.0028 \times \frac{1}{2} = 0.0014$ *[1 mark]*

$m(\text{S theoretical}) = 0.0014 \times 32.06 = 0.045$ g *[1 mark]*

Percentage yield $= \frac{0.039}{0.045} \times 100 = 87\%$ *[1 mark]*

QUESTION 4 (10 marks)

a) i)

Element	Protons	Shielding electrons	Effective nuclear charge
nitrogen	7	2	5
magnesium	12	**10**	2
phosphorus	15	10	**5**

[2 marks]
1 mark for each correct answer.

ii) Nitrogen and phosphorus are in the same group/have the same effective nuclear charge, but phosphorus has an extra shell/energy level. *[1 mark]*

Therefore the valence electrons in phosphorus are further away from the nucleus. *[1 mark]*

Magnesium and phosphorous are in the same period, so they have the same number of shells and shielding electrons. *[1 mark]*

Phosphorus has more protons than magnesium, so it has a higher effective nuclear charge. *[1 mark]*

Therefore the valence electrons of phosphorus are pulled closer to the nucleus. *[1 mark]*

b) Accept 9000–12 000 *[1 mark]*

Al has three valence electrons, therefore the fourth electron is from the second shell. *[1 mark]*

This makes it significantly more difficult to remove than the third electron, but not quite as difficult as the fifth. *[1 mark]*

QUESTION 5 (6 marks)

a) substance 4 OR 8 *(high conductivity as solid and not brittle – dents rather than shattering)* *[1 mark]*

b) $C_{20}H_{42}$ *(as substance 6 has low melting and boiling points, indicating molecular, not ionic)* *[1 mark]*

c) Substance 2 is ionic. *[1 mark]*

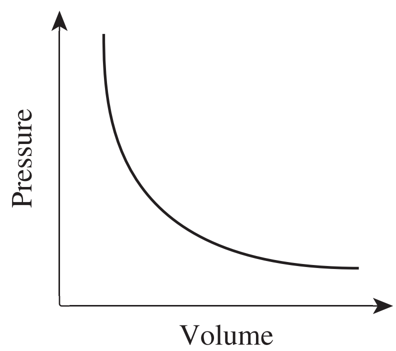
Any three of the following reasons:

- A high melting point indicates strong electrostatic attraction.
- Solubility in water indicates the presence of ions/polar areas.
- Shattering indicates the presence of ions in rigid/fixed lattice.
- Lack of conductivity as a solid and solubility when dissolved/molten confirms the presence of ions, held in a lattice at room temperature.

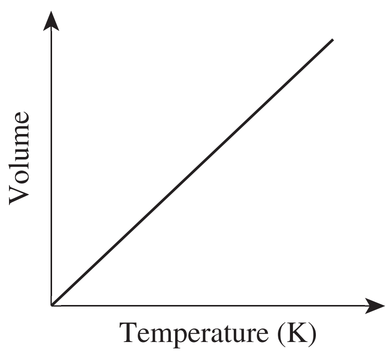
[3 marks]

QUESTION 6 (9 marks)

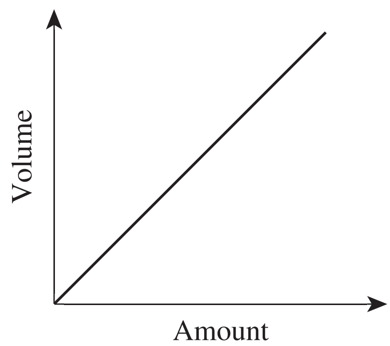
a) i)



ii)



iii)



[3 marks]
1 mark for each correct graph.

b) $n(H_2) = \frac{58.2}{22.7} = 2.56$ *[1 mark]*

number of molecules $= 2.56 \times 6.02 \times 10^{23} = 1.54 \times 10^{24}$ *[1 mark]*

c) $n(\text{Ar}) = \frac{200}{39.95} = 5.0$ *[1 mark]*

$T = -20 + 273 = 253$ K *[1 mark]*

$V = \frac{5.0 \times 8.31 \times 253}{180} = 58$ L *[1 mark]*

d) *Any one of:*

- volume occupied by gas particles becomes significant
- effect of IMFs becomes significant

[1 mark]

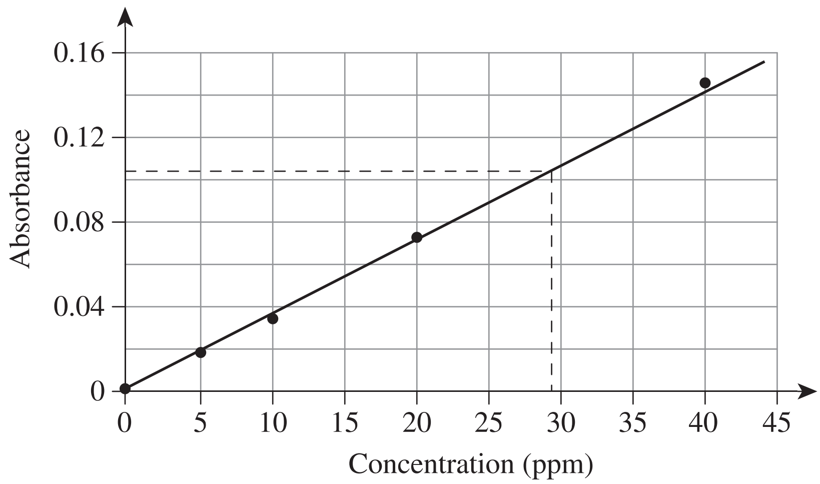
QUESTION 7 (11 marks)

a) Both techniques utilise the energy emitted by excited electrons as they return to their ground state. *[1 mark]*

In a flame test, this energy is combined into a single colour, *[1 mark]*
whereas atomic emission spectroscopy (AES) produces a line spectrum. *[1 mark]*

Both techniques can be used to identify elements, but some elements produce similar flame colours, *[1 mark]*
whereas the line spectrum from AES is characteristic to each element, making this technique more accurate. *[1 mark]*

b) i)



[1 mark]

28–29 ppm *[1 mark]*

ii) concentration of soil solution = 29 ppm = 0.029 g/L *[1 mark]*

mass of iron in soil sample $= 0.029 \times 0.2500 = 0.00725$ g *[1 mark]*

$\%(\text{m/m})$ of soil $= \frac{0.00725}{3.27} \times 100 = 0.22\%$ *[1 mark]*

This is below the acceptable range, so the soil is not suitable. *[1 mark]*