States of Matter

Mark Scheme 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	States of Matter
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **64 minutes**

Score: **/53**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)**

$$\begin{array}{c} \phantom{H^x{}_oC}{}^{x}{}_{o} \\ H^{x}{}_{o}C^{x}{}_{o}C^{o}{}_{x}H \\ \phantom{H^x{}_oC}{}^{x}{}_{o} \end{array}$$

(1) **[1]**

(b) $n = \frac{PV}{RT} = \frac{(1515 \times 10^{3}) \times (76 \times 10^{-3})}{8.31 \times 298}$ **(1)**

$= 46.5$ **(1)** **[2]**

(c) **(** $CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$ **(1)**

(ii) $n(C_2H_2) = n(CaC_2) = 100 \times 46.5$ **(1)**

mass of $CaC_2 = 100 \times 46.5 \times 64 =$

$= 297\ 570$ g

$= 297.6$ kg (accept 298 kg)

correct units necessary **(1)**

allow e.c.f. on candidate's answer in **(b)** **[3]**

(d) $C_2H_2(g) + {}^{5}/_{2}O_2(g) \rightarrow 2CO_2(g) + H_2O(g)$

bonds broken:	2(H-C)	2 x 410	=	820	
	C≡C	840	=	840	
	$^{5}/_{2}$(O=O)	$^{5}/_{2}$ x 496	=	1240	
				2900 kJ mol^{-1}	**(1)**
bonds made:	4(C=O)	4 x 7	=	2960	
	2(O-H)	2 x 460	=	920	
				3880 kJ mol^{-1}	**(1)**

$\Delta H_{comb} = -3880 + 2900 = -980$ kJ mol^{-1} **(1)**

allow e.c.f. on incorrect bonds made/broken **[3]**

(e) **(i)** the enthalpy/energy change when one mole of a substance **(1)**

is burned in an excess of air/oxygen
or completely combusted
under standard conditions **(1)**

(ii) calculation in **(d)** includes $H_2O(g)$ whereas ΔH_{comb} involves $H_2O(l)$
or average bond energy terms are used in the *Data Booklet* **(1)** **[3]**

[Total: 12]

2 **(a)** The volume of the gas molecules / atoms / particles is insignificant compared with the volume of the vessel.
There are no forces of attraction between the gas molecules.
All collisions by the gas molecules are perfectly elastics. Any <u>two</u>.
[2]

(b) **(** The pressure of / exerted <u>by the gas</u>. [1]
Pa / Nm^{-2} [1]

(ii) The volume of the containing vessel [1]
m^3 / dm^3 / cm^3 [1]

(iii) The absolute temperature [1]
In K <u>or</u> 273 + °C [1]

(c) **(i)** $pV \approx w/m \times RT$

$m = (0.103 \times 8.31 \times 297) / (99.5 \times 10^3 \times 63.8 \times 10^{-6})$ [1]
= 40.0 [1]

The gas is argon [1]

(ii) The hydrogen bonds between ammonia molecules (1)
are stronger than the Van De Waals' forces between N_2 and Ar molecules (1)

Ammonia is polar / has a dipole (1)

(Any two) [2]

Total = [13]

3 **(a)** **(i)** That the volume of the gas molecules is negligible compared to the volume of gas (1)

(ii) That there are no intermolecular forces
OR collisions of the molecules are perfectly elastic
Particles are in constant motion, losing no energy on collision (1) any two **[2]**

(b) 6.02×10^{23} (1) **[1]**

(c) **(i)** r = <u>0.192</u> nm (1) Assume most candidat 3

$v = \frac{4}{3} \times 3.14 \times (1.92 \times 10^{-9})^3 = 2.96 \times 10^{-26}$ dm^3 (2.96×10^{-29} m^3) (1)

(ii) $2.96 \times 10^{-26} \times \underline{6.02 \times 10^{23}}$ (1) = 1.78×10^{-2} dm^3 (1.78×10^{-5} m^3) (1)

(iii) 24 dm^3 (0.024 m^3) (1)

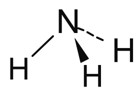
(iv) $\frac{1.78 \times 10^{-2} \times 10^2}{24}$ = 0.074% (1)

(v) Some statement which connects with **(a) (i)** above (1) **max [5]**

(d)
- hot metals will react with oxygen in air (or nitrogen)
- to form oxides/will burn out/to a powder
- argon will not react
- at high temperatures O_2 and N_2 in air will react to give NO_x

NOT expansion of gases on heating any two **[2]**

[Total: 10]

Question	Scheme	Marks	T
4 **(a)**	$CH_4 + H_2O \rightarrow CO + 3H_2$	1	[1
(b)	Label on graph indicating catalysed and uncatalysed Ea OR statement Ea catalysed is lower (than Ea uncatalysed) owtte Reference to catalyst creating alternative mechanism / reaction pathway / route Idea that more molecules have sufficient energy (to react) so greater chance / frequency of successful collisions	1 1 1 1	 [4]
(c)	 angle = 107° shape = (trigonal) pyramid(al)	1 1 1	 [3]
(d) **(i)**	Advantage = higher rate Greater Kinetic Energy / speed / collision frequency / proportion of successful collisions Disadvantage – reduced yield / less product / more reactants (Forward reaction) **exothermic AND** (hence in accordance with Le Chatelier's Principle) equilibrium / reaction **shifts left** (to counteract increasing temp) ora	1 1 1 1	 [4]
(ii)	$K_p = \dfrac{pNH_3^{\,2}}{pN_2 \times pH_2^{\,3}}$	1	[1]

(iii)	$N_2(g)$ + $3H_2(g)$ ⇌ $2NH_3(g)$ 2 3 0 (–0.8) (–1.6×3/2) 1.2 0.6 1.60 xNH_3 = 1.6/3.4 (= 0.471) xN_2 = 1.2/3.4 (= 0.353) xH_2 = 0.6/3.4 (= 0.176) $K_p = \dfrac{0.471^2 \times (2 \times 10^7)^2}{0.353 \times 2 \times 10^7 \times 0.176^3 \times (2 \times 10^7)^3} = 2.88 \times 10^{-13}\ Pa^{-2}$	1 1 1+1	[5]
			[18]