1.

A solution contains 0.25 g of sulfur dioxide in 1.00 dm^3 of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of 1×10^5 Pa, must be added to 1.00 dm^3 of water to produce this solution?

A 0.0162 cm^3 **B** 0.105 cm^3 **C** 16.2 cm^3 **D** 105 cm^3

$$pV = \frac{m}{Mr}RT$$

$$V = ((\frac{0.25}{32+2\times16} \times 8.31 \times (50 + 273)) \div 10^5) \times 1000$$

NOTE: the pV = nRT equation measures volume in m3 NOT dm3
1m3 = 1000dm3 = 1000000cm3

2.

Flask Q contains 5 dm^3 of helium at 12 kPa pressure. Flask R contains 10 dm^3 of neon at 6 kPa pressure.

If the flasks are connected at constant temperature, what is the final pressure?

A 8 kPa **B** 9 kPa **C** 10 kPa **D** 11 kPa

$P_1V_1 = P_2V_2$
$5 \times 12 \times 10^3 + 10 \times 6 \times 10^3 = P_2 \times 15$
$P_2 = 8000 = 8kPa$

3.

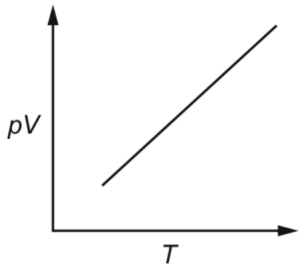
Which substance shows the greatest deviation from the properties of an ideal gas under room conditions?

A $CO_2(g)$ **B** $H_2(g)$ **C** Ne(g) **D** $NH_3(g)$

Ans: D
NH3 has H–bonds, so IMFs are strong.

4.

A graph of pV against T is shown for a fixed mass of gas. (p = pressure, V = volume and T = temperature in K.)



Which gas gives this graph over the widest range of temperatures and pressures?

A hydrogen, H_2

B hydrogen chloride, HCl

C hydrogen fluoride, HF

D oxygen, O_2

Ans: A

Graph of pV against T is linear over a wide range of temperatures and pressures for ideal gases.

5.

Under which conditions will nitrogen behave most like an ideal gas?

	temperature	pressure
A	low	high
B	high	low
C	low	low
D	high	high

Ans: B

6.

1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

A calcium

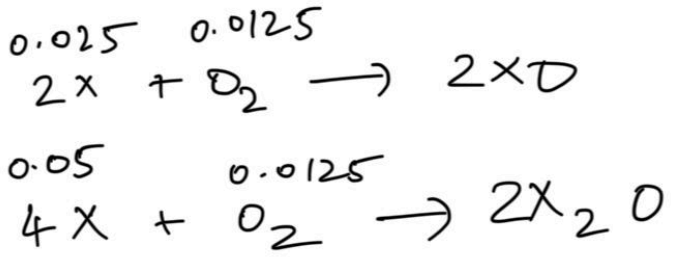
B magnesium

C potassium

D sodium

Ans: D

No. of mol of O2 = 300/24000 = 0.0125



1.15/23 = 0.05

7.

X, Y and Z are all gases that behave ideally and react according to the equation shown.

$$X(g) + 2Y(g) \rightarrow 2Z(g)$$

When 3.0 mol of X and 3.0 mol of Y are placed inside a container with a volume of 1.0 dm^3, they react to form the maximum amount of Z.

The final temperature of the reaction vessel is 120 °C.

What is the final pressure inside the reaction vessel?

A 4.49×10^6 Pa

B 9.80×10^6 Pa

C 1.47×10^7 Pa

D 1.96×10^7 Pa

Ans: C
1.5X + 3Y = 3Z
No of moles initially = 4.5
P1V1 = P2V2
Initial P = (4.5 x 8.31 x (120+273)) / (1/1000) = 14696235
14696235 x (1/1000) = P2 x (1/1000)
So P2 = 14696235

8.

What changes in conditions or molecular properties make it more likely that gases approach ideal behaviour?

A higher pressure

B lower temperature

C more polar molecules

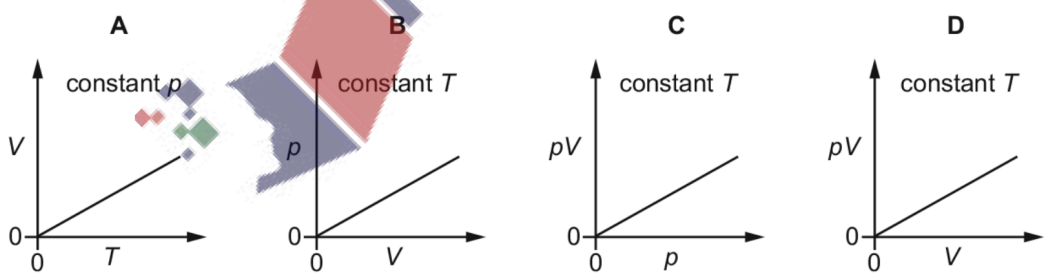
D weaker intermolecular forces

Ans: D

CAREFUL: question asks for approaching ideal behaviour, not deviating from it.

9.

Which diagram correctly describes the behaviour of a fixed mass of an ideal gas? (*T* is measured in K.)



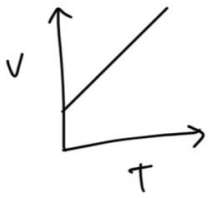
Ans: A

For an ideal gas,

- volume is directly proportional to temperature.
- volume is inversely proportional to pressure.
- pV is directly proportional to T

When T is measured in K, graph starts from 0.

If it is measured in celsius,



NOTE: 1atm = 101325 Pa

10.

Exactly 1.00 g of a metallic element reacts completely with 300 cm^3 of oxygen at 298 K and 1 atm pressure to form an oxide which contains O^{2-} ions.

The volume of one mole of gas at this temperature and pressure is 24.0 dm^3.

What could be the identity of the metal?

A calcium

B magnesium

C potassium

D sodium

Ans: A

11.

Which gas sample contains the **fewest** molecules?

A 1.00 dm^3 of carbon dioxide at 27 °C and 2.0 kPa

B 1.00 dm^3 of hydrogen at 100 °C and 2.0 kPa

C 1.00 dm^3 of nitrogen at 300 °C and 4.0 kPa

D 1.00 dm^3 of oxygen at 250 °C and 3.0 kPa

Ans: B

Calculate value of n in each case. Lowest value of n = fewest molecules.

n = no. of moles

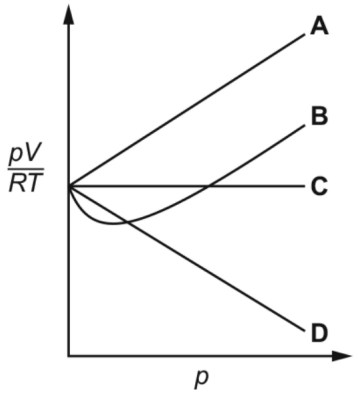
No further calculation to account for the different gases is required, because 1 mol consists of the same name number of molecules.

12.

A sample of an ideal gas is contained at a constant temperature of 300 K in a gas syringe.

The pressure is increased and a graph of $\frac{pV}{RT}$ against pressure is plotted.

Which graph correctly represents the results?



Ans: C

- pV/RT = n
- Increase in p has no effect on n
- n is constant for a sample of an ideal gas

13.

0.10 g of the volatile liquid X formed 0.025 dm^3 of vapour at 100 °C and atmospheric pressure.

1 mol of vapour occupies 22.4 dm^3 at 0 °C and atmospheric pressure.

What is the relative molecular mass of X?

A $\frac{0.025 \times 273 \times 22.4}{0.10 \times 373}$

B $\frac{0.025 \times 373 \times 22.4}{0.10 \times 273}$

C $\frac{0.10 \times 273 \times 22.4}{0.025 \times 373}$

D $\frac{0.10 \times 373 \times 22.4}{0.025 \times 273}$

Ans: D

$pV = nRT$

$\Rightarrow p \times 0.025 \times 10^{-3} = \frac{0.1}{M_r} \times R \times 373$

$M_r = \frac{0.1 \times R \times 373}{p \times 0.025 \times 10^{-3}}$

$pV = nRT$

$\Rightarrow p = \frac{1 \times R \times 273}{22.4 \times 10^{-3}}$

$M_r = \frac{0.1 \times R \times 373 \times 22.4 \times 10^{-3}}{0.025 \times 10^{-3} \times R \times 273} = \frac{0.1 \times 373 \times 22.4}{0.025 \times 273}$

14.

The approximate percentage composition of the atmospheres on four different planets is given in the table below.

Which mixture of gases has the greatest density?

	planet	major gases / % by number of molecules		
		H_2	He	CH_4
A	Jupiter	89.8	10.2	0.0
B	Neptune	80.0	19.0	1.0
C	Saturn	96.3	3.3	0.4
D	Uranus	82.5	15.2	2.3

Ans: D

15.

In an experiment, a sample of a pure gas is put into a gas syringe at a temperature of 300 K and pressure of 16 kPa. The gas is compressed until the volume occupied by the gas is halved.

After compression, the temperature of the gas in the syringe is 375 K and the pressure is 40 kPa.

Which statement is correct?

A Intermolecular forces between the gas molecules are significant.

B It is possible to calculate the number of moles of gas present using these data alone.

C The gas is behaving ideally.

D The pressures used are too high for ideal gas behaviour.

Ans: C

If the gas behaves ideally, PV α T

16V = 300

40 x (V/2) = 375; 20V = 375

300/16 = 375/20, thus PV α T, so the gas behaves ideally

16.

1.00 g of carbon is combusted in a limited supply of pure oxygen. 0.50 g of the carbon combusts to form CO_2 and 0.50 g of the carbon combusts to form CO.

The resultant mixture of CO_2 and CO is passed through excess NaOH(aq) and the remaining gas is then dried and collected.

What is the volume of the remaining gas? (All gas volumes are measured at 25 °C and 1 atmosphere pressure.)

A 1 dm^3 **B** 1.5 dm^3 **C** 2 dm^3 **D** 3 dm^3

Ans: A

$\frac{1}{24}$ $C + O_2 \rightarrow \frac{1}{24}$ CO_2

$\frac{1}{24}$ $C + \frac{1}{2}O_2 \rightarrow \frac{1}{24}$ CO

$CO_2 + CO + NaOH$

CO_2 reacts w/ NaOH

but CO does not

CO_2 = acidic

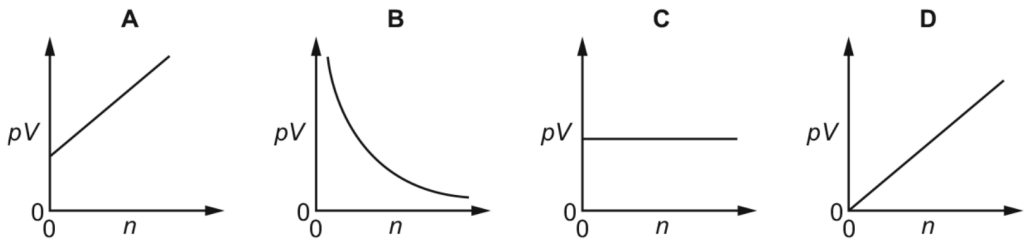
CO = neutral

∴ vol of CO to be calc =

$\frac{1}{24} \times 24 = 1\ dm^3$

17.

Which diagram shows the correct graph of *pV* against *n* for an ideal gas at constant temperature?



Ans: D

- pV / n = RT
- RT = gradient
- R is constant, T is constant (given)
- RT is constant, so gradient is constant
- In option C, gradient = RT = 0!
- Cannot be option A since there is no intercept: pV = nRT; If there was an intercept, equation would be of the form pV = nRT + c
- Thus ans = D

18.

Use of the Data Booklet is relevant to this question.

4.70 g of an ammonium salt is heated with excess aqueous sodium hydroxide. The volume of ammonia gas given off, measured at room temperature and pressure, is 1.41 dm^3.

Which ammonium salt was used?

A ammonium bromide (M_r = 97.9)

B ammonium carbonate (M_r = 96)

C ammonium nitrate (M_r = 80)

D ammonium sulfate (M_r = 132.1)

Ans: C

1:1 ratio of NH3 and ammonium salt

No of mol of NH3 = 1.41/24 = 0.05875

No of mol of NH4NO3 = 4.7/80 = 0.05875

19.

Sodium chloride, water and air represent three states of matter – solid, liquid and gas.

Which row is correct?

	sodium chloride	water	air
A	particles held in rigid structure	can easily be compressed	can easily be compressed
B	particles stationary	particles move	cannot easily be compressed
C	particles stationary	particles stationary	particles move
D	resistant to change of shape	cannot easily be compressed	can easily be compressed

Ans: D

- NaCl is ionic, so it is brittle, NOT malleable, so resistant to shape.
- Liquids cannot be easily compressed

20.

In which carbon allotrope are all electrons localised?

A buckminsterfullerene

B diamond

C graphite

D graphene

Ans: B

Localised ≠ delocalised

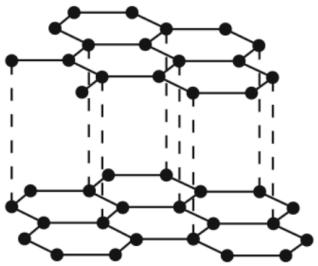
In diamond, all 4 valence electrons form covalent bonds.

NOTE: structure of solid CO_2 is similar to structure of solid I_2; both have lattice structures.

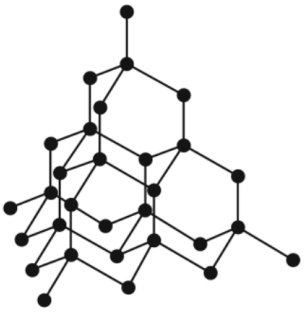
21.

P, Q and R represent three different structures of an element.

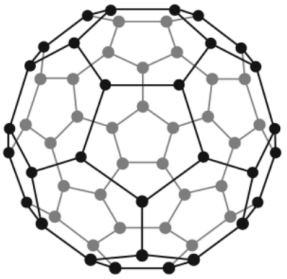
P



Q



R



Which structures are giant molecular?

A P, Q and R

B P and Q only

C P and R only

D Q and R only

Ans: B

22.

Element W is in period three of the Periodic Table and has a solid, white oxide, X. X is thermally stable and has a very high melting point.

X is slightly soluble in water.

Which row describes the structure and bonding of X?

	structure	bonding
A	giant three dimensional lattice	covalent
B	strong double bonds within small molecules	covalent
C	giant three dimensional lattice	ionic
D	strong ionic bonds within small molecules	ionic

Ans: C

- Period 3 metal and oxygen, high mp = ionic
- Cannot be option D, as ionic bonds are not <u>within</u> small <u>molecules</u>

NOTE: CH3F has pd–pd forces NOT H–bonding, as there is no H–F grp in CH3F.

23.

Which solid contains more than one type of bonding?

A iodine

B silicon dioxide

C sodium chloride

D zinc

Ans: A

- Iodine has strong covalent bonds & weak id-id forces.
- SiO2 DOES NOT have IMFs, only covalent bonds are present.

24.

Which row describes the structure and bonding of SiO_2 and $SiCl_4$?

	SiO_2		$SiCl_4$	
	bonding	structure	bonding	structure
A	covalent	giant	covalent	giant
B	covalent	giant	covalent	simple
C	ionic	giant	covalent	giant
D	ionic	giant	covalent	simple

Ans: B

25.

In the sodium chloride lattice the number of chloride ions that surround each sodium ion is called the *co-ordination number* of the sodium ions.

What are the co-ordination numbers of the sodium ions and the chloride ions in the sodium chloride lattice?

	sodium ions	chloride ions
A	4	6
B	6	4
C	6	6
D	8	6

Ans: C

26.

An article in a science magazine contains the following statement.

'It is lighter than a feather, stronger than steel, yet incredibly flexible and more conductive than copper.'

Which form of carbon is being described?

A buckminsterfullerene

B diamond

C graphene

D graphite

Ans: C

27.

Which solid has a simple molecular lattice?

A calcium fluoride

B nickel

C silicon(IV) oxide

D sulfur

Ans: D

28.

Three substances have the physical properties shown in the table.

substance	melting point /°C	boiling point /°C	conductivity (solid)	conductivity (liquid)	conductivity (aqueous)
U	420	907	good	good	insoluble
V	993	1695	poor	good	good
W	–70	58	poor	poor	hydrolyses, resulting solution conducts well

What could be the identities of **U**, **V** and **W**?

	U	**V**	**W**
A	Na	KCl	$SiCl_4$
B	Na	NaF	C_2H_5Br
C	Zn	KCl	HCl
D	Zn	NaF	$SiCl_4$

Ans: D

- Na is soluble in water, so options A and B can be eliminated

- W is a liquid at rtp
- HCl is a gas at rtp; SiCl4 is a liquid at rtp
- Thus W has to be SiCl4

29.

In this question you should assume that the gas formed behaves as an ideal gas.

A 1.7 g sample of Mg reacts with 50.0 cm^3 of 2.2 mol dm^{-3} HCl at 303 K and 110 400 Pa.

Which volume of gas is produced, measured under these conditions?

A 1.3 dm^3 **B** 1.6 dm^3 **C** 2.5 dm^3 **D** 5.0 dm^3

Ans: A

30.

When an evacuated tube of volume 400 cm^3 is filled with gas at 300 K and 101 kPa, the mass of the tube increases by 0.65 g.

Assume the gas behaves as an ideal gas.

What is the identity of the gas?

A argon

B helium

C krypton

D neon

Ans: A

$$M_r = \frac{mRT}{PV} = \frac{0.65 \times 8.31 \times 300}{101 \times 10^3 \times \frac{400}{100^3}} = 40.1$$

31.

Which statement explains why buckminsterfullerene has a lower melting point than graphite?

A Buckminsterfullerene exists as discrete molecules with weak intermolecular bonding.

B Graphite is partly ionic as its structure contains mobile electrons and it conducts electricity.

C The carbon–carbon bonds in buckminsterfullerene are shorter and more strained.

D The mobile electrons in graphite mean it has a metallic structure.

Ans: A

32.

In an experiment, 0.100 mol of propan-1-ol is burnt completely in 12.0 dm^3 of oxygen, measured at room conditions.

What is the final volume of gas, measured at room conditions?

A 7.20 dm^3 **B** 8.40 dm^3 **C** 16.80 dm^3 **D** 18.00 dm^3

Ans: B

$$\underset{0.1}{C_3H_7OH} + \underset{0.45}{\frac{9}{2}O_2} \longrightarrow \underset{0.3}{3CO_2} + \underset{0.4}{4H_2O}$$

vol of CO_2 produced $= 0.3 \times 24 = 7.2$

vol of O_2 unused $= (0.5 - 0.45) \times 24 = 1.2$

$\therefore 7.2 + 1.2 = 8.4\ dm^3$ gas

33.