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Basic Education

KwaZulu-Natal Department of Basic Education

REPUBLIC OF SOUTH AFRICA

PHYSICAL SCIENCES P2 (CHEMISTRY)

COMMON TEST

JUNE 2016

NATIONAL SENIOR CERTIFICATE

GRADE 11

MARKS: 100

TIME : 2 hours

This question paper consists of 7 pages, and 2 data sheets.

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INSTRUCTIONS AND INFORMATION

1. Answer all questions.
2. Non-programmable calculators may be used.
3. Number the answers correctly according to the numbering system used in this question paper.
4. Be brief whenever motivations, discussions, et cetera, are required.
5. Leave ONE line between two sub-questions, for example between QUESTION 3.1 and QUESTION 3.2.
6. Show the formulae and substitutions in ALL calculations.
7. Round off your final answer to two (2) decimal places, unless otherwise stated.

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QUESTION 1: MULTIPLE CHOICE

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write down only the letter (A – D) next to the question number (1.1 – 1.6) in the answer book for example 1.1 D.

1.1 What is the molecular shape and polarity of a SF_6 molecule?

A Octahedral and polar

B Trigonal bipyramidal and plar

C Octahedral and non- polar

D Hexahedral and non-polar (2)

1.2 Which one of the following sequences shows compounds arranged in order of decreasing ionic properties:

A CsF, CaO, LiI

B CaO, LiI, CsF

C LiI, CsF, CaO

D CsF , LiI, CaO (2)

1.3 At room temperature chlorine is a gas, bromine is a liquid and iodine is a solid. The best reason for the different states of these molecules room temperature is that ...

A they have different types of intermolecular forces

B their bonds have different polarities

C the strengths of the dipole-dipole forces differ in each molecule.

D they have different molecular masses (2)

1.4 Two different gases are at the same temperature and pressure. If they contain the same number of molecules, then these gases....

A Have the same mass.

B Have the same volume.

C Occupy 22,4 dm^3 at STP.

D Have the same number of atoms. (2)

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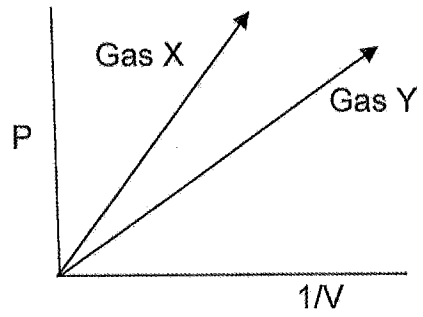
1.5 The relationship between pressure and volume of two different gases, X and Y, was determined experimentally and the relationship was represented graphically.



From the above graphs, it can be concluded that the:

A apparatus contained more moles of gas X than gas Y.

B temperature of gas X was not kept constant.

C temperature of gas Y was not kept constant.

D apparatus contained more moles of gas Y than gas X. (2)

1.6 A standard solution...

A contains one mole of solute per dm^3.

B must always be made up to 1 dm^3.

C is a solution of which the concentration is precisely known.

D is a solution made of oxalic acid. (2)

[12]

QUESTION 2

2.1 Phosphine, PH_3, is a colourless, toxic gas. It is formed when phosphorus reacts with hydrogen.

2.1.1 Name the type of chemical bond between phosphorus and hydrogen. (1)

2.1.2 Draw the Lewis structure for the phosphine molecule. (2)

2.1.3 What is the geometric shape of the phosphine molecule? (2)

2.2 Phosphine reacts with a hydrogen ion to form PH_4^+

2.2.1 Name the type of bond between phosphorus and the hydrogen ion in PH_4^+. (1)

2.2.2 How many electrons surround the central atom in PH_4^+? (2)

2.2.3 What is the geometric shape of PH_4^+? (2)

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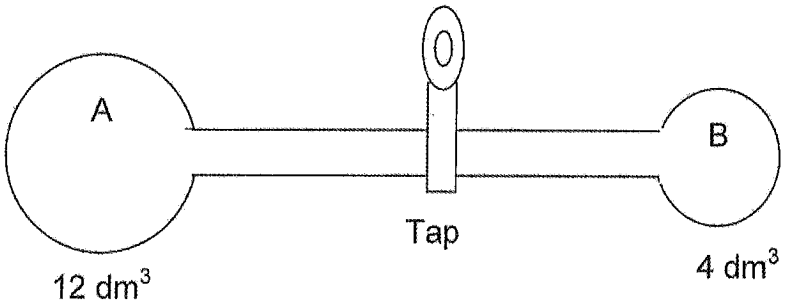
2.3 Ammonia, NH_3, and phosphine, are molecules that have the same geometric shape.
Explain why is the boiling point of NH_3 greater than that of PH_3? (3)

2.4 Which one of iodine, I_2, or calcium chloride, $CaCl_2$, will be more soluble in carbon tetrachloride, CCl_4? Explain your answer by referring to the types of forces present between the particles. (5)
[18]

QUESTION 3

3.1 State in words, Boyle's law. (2)

3.2 Two gas spheres, A and B, of volumes $12dm^3$ and $4\ dm^3$ respectively, are connected by a glass tube and a closed tap.

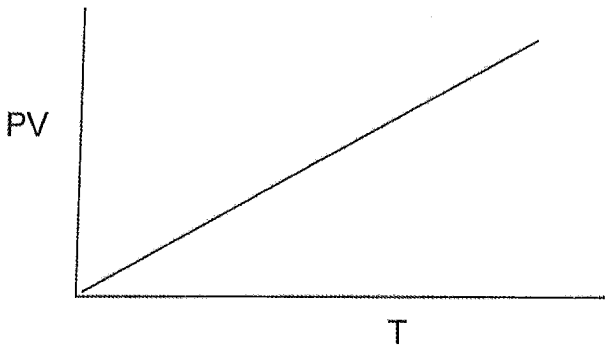


The pressure in A is recorded as 250 kPa, whilst B does not contain any gas. Both spheres are maintained at 27 °C.
The tap is now opened. (Ignore the volume of the connecting tube)

3.2.1 Calculate the new pressure of the gas at 27 °C. (4)

3.2.2 How will the pressure of the gas in sphere A compare to that in sphere B? (Choose from: GREATER THAN, LESS THAN OR EQUAL TO) (2)

3.3 A diatomic gas was studied at various temperatures and pressures. The following graph was obtained from results of the study.



Assume that this gas an ideal gas.

3.3.1 List three properties of an ideal gas. (3)

3.3.2 State the conditions under which real gases deviate from ideal gas behaviour. (2)

3.3.3 Determine the gradient of this graph, if the gas occupied 3,36 dm^3 at STP. (4)

3.3.4 0,384 g of this gas occupied a volume of 200,00 cm^3 at a pressure of 149,58 kPa and temperature of 27°C.
Identify this gas. Show clearly how you arrived at this answer. (6)
[23]

QUESTION 4

A laboratory analysis of an organic compound gave the following mass percent composition:

Carbon: 60,00%

Hydrogen: 4,48%

Oxygen: 35,52%

4.1 Distinguish between empirical formula and molecular formula. (2)

4.2 Determine the empirical formula of this compound. (9)

The molar mass of the compound is 540 $g.mol^{-1}$

4.3 Determine the molecular formula of this compound. (2)
[13]

QUESTION 5

5.1 Sulphur reacts with iron according to the equation:

$$Fe + S \rightarrow FeS$$

The reaction requires large amount of heat.

When 2,5 g sulphur and 5 g iron were placed in a test tube and heated strongly, a reaction took place to produce a greyish black solid. After the reaction was completed the solid was found to be magnetic.

5.1.1 Why was this greyish black solid magnetic? (2)

5.1.2 Calculate the mass of FeS produced. (6)

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5.2 Calcium carbide, CaC_2, is produced industrially according to the reaction:

$$CaO + 3C \rightarrow CaC_2 + CO$$

In a reaction, 1,5 kg of carbon was reacted with calcium oxide and 2,42 kg of calcium carbide was produced. Calculate the percentage yield of calcium carbide. (8)

5.3 An impure sulphide ore sample contains 40,50% zinc. Calculate the percentage pure zinc sulphide, ZnS, in this ore. (6)

[22]

QUESTION 6

A standard solution is prepared by dissolving 20,8 g barium chloride, $BaCl_2$, in water and made up to 250,00 cm^3 in a volumetric flask.

6.1 Calculate the concentration of this solution. (5)

6.2 What is the concentration of the chloride ions in this solution? (2)

100 cm^3 of this solution is poured into a beaker.

6.3 How much water must now be added to the beaker to give a solution of concentration of 0,10 $mol.dm^{-3}$? (5)

[12]

TOTAL MARKS: [100]

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DATA FOR PHYSICAL SCIENCES GRADE 11

PAPER 2 (CHEMISTRY)

TABLE 1: PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Standard pressure	p^{θ}	$1{,}013 \times 10^5$ Pa
Molar gas volume at STP	V_m	22,4 $dm^3 \cdot mol^{-1}$
Standard temperature	T^{θ}	273 K
Charge on electron	e	$-1{,}6 \times 10^{-19}$C
Avogadro's constant	N_A	$6{,}02 \times 10^{23}$ mol^{-1}
Gas constant	R	8,31J.mol^{-1}.K^{-1}

TABLE 2: FORMULAE

$n = \frac{m}{M}$	$n = \frac{N}{N_A}$
$c = \frac{n}{V}$ OR $c = \frac{m}{MV}$	$n = \frac{V}{V_m}$
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	PV = nRT

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TABLE 3: THE PERIODIC TABLE OF ELEMENTS

1 (I)	2 (II)	3	4	5	6	7	8	9	10	11	12	13 (III)	14 (IV)	15 (V)	16 (VI)	17 (VII)	18 (VIII)
2,1 H 1																	2 He 4
1,0 Li 7	1,5 Be 9											2,0 B 11	2,5 C 12	3,0 N 14	3,5 O 16	4,0 F 19	10 Ne 20
0,9 Na 23	1,2 Mg 24											1,5 Aℓ 27	1,8 Si 28	2,1 P 31	2,5 S 32	3,0 Cℓ 35,5	18 Ar 40
0,8 K 39	1,0 Ca 40	1,3 Sc 45	1,5 Ti 48	1,6 V 51	1,6 Cr 52	1,5 Mn 55	1,8 Fe 56	1,8 Co 59	1,8 Ni 59	1,9 Cu 63,5	1,6 Zn 65	1,6 Ga 70	1,8 Ge 73	2,0 As 75	2,4 Se 79	2,8 Br 80	36 Kr 84
0,8 Rb 86	1,0 Sr 88	1,2 Y 89	1,4 Zr 91	41 Nb 92	1,8 Mo 96	1,9 Tc	2,2 Ru 101	2,2 Rh 103	2,2 Pd 106	1,9 Ag 108	1,7 Cd 112	1,7 In 115	1,8 Sn 119	1,9 Sb 122	2,1 Te 128	2,5 I 127	54 Xe 131
0,7 Cs 133	0,9 Ba 137	57 La 139	1,6 Hf 179	73 Ta 181	74 W 184	75 Re 186	76 Os 190	77 Ir 192	78 Pt 195	79 Au 197	80 Hg 201	1,8 Tℓ 204	1,8 Pb 207	1,9 Bi 209	2,0 Po	2,5 At	86 Rn
0,7 Fr	0,9 Ra 226	89 Ac															

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce 140	Pr 141	Nd 144	Pm	Sm 150	Eu 152	Gd 157	Tb 159	Dy 163	Ho 165	Er 167	Tm 169	Yb 173	Lu 175
90 Th 232	91 Pa	92 U 238	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

KEY/*SLEUTEL*

Atomic number
Atoomgetal

Electronegativity
Elektronegatiwiteit

Symbol
Simbool

Approximate relative atomic mass
Benaderde relatiewe atoommassa

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N.B. This memorandum consists of 6 pages.

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QUESTION 1

1.1 C ✓✓ (2)

1.2 C✓✓ (2)

1.3 C✓✓ (2)

1.4 B✓✓ (2)

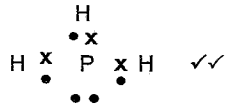
1.5 A ✓✓ (2)

1.6 C ✓✓ (2)
[12]

QUESTION 2

2.1

2.1.1 Convalent bond ✓ (1)

2.1.2  ✓✓ (2)

2.1.3 Trigonal pyramid ✓ ✓ (1)

2.2.1 Dative covalent bond ✓ (1)

2.2.2 18 ✓✓ (2)

2.2.3 tetrahedral ✓✓ (2)

2.3 NH_3 has hydrogen bonds whereas PH_3 has dipole-dipole forces. ✓ Hydrogen bonds are stronger than dipole-dipole forces. ✓Hence more energy is required to separate NH_3 molecules when boiling it. ✓ (3)

2.4 Iodine ✓
In I_2 and CCl_4, the molecules are held together by weak van der Waals forces. ✓ The forces are of comparable strength. ✓ Hence CCl_4 and Iodine will dissolve in each other.
$CaCl_2$ has very strong ionic bonds ✓between the ions which cannot be broken by CCl_4. ✓ (5)
[18]

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QUESTION 3

3.1 The volume of a given mass of gas is inversely proportional to the pressure exerted on it, provided that the temperature remains constant. ✓✓ (2)

3.2.1 $P_1 V_1 = P_2 V_2$ ✓
$250 \times 12 = P_2 \times 16$ ✓
$P_2 = 187{,}50 kPa$ ✓ (4)

3.2.2 Equal to ✓✓ (2)

3.3.1 - Particles are in continual motion in all directions
- Particles are very small and together do not contribute to the volume of gas.
- The particles of an ideal gas exert no forces on one another nor on the sides of the container.
- All particles are identical.
- The collisions between ideal gas particles and between particles and sides of the container are perfectly elastic.

Any three ✓✓✓ (3)

3.3.2 High pressure ✓
Low temperature ✓ (2)

3.3.3 **OPTION 1**

$\frac{PV}{T} = \text{gradient}$ ✓
$\frac{101{,}3 \times 10^3 \times 3.36 \times 10^{-3}}{273{,}15} = \text{gradient}$ ✓
$1{,}246 J.K^{-1} = \text{gradient}$ ✓

OPTION 2

$n = \frac{V}{V_m}$ ✓
$= \frac{3{,}36}{22{,}4}$ ✓
$= 0{,}15 mol$
$nR = \text{gradient}$ ✓
$0{,}15 \times 8{,}314 = \text{gradient}$
$1{,}247 J.K^{-1} = \text{gradient}$ ✓ (4)

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3.3.4 $PV = nRT$ ✓
$\frac{149{,}58 \times 0{,}2}{300 \times 8{,}31} = n$ ✓
$0{,}012 mol = n$ ✓
$n = \frac{m}{m}$
$0{,}012 = \frac{0{,}384}{M}$ ✓
$M = 32 g\,mol^{-1}$ ✓
$\therefore$ gas is O_2 ✓ (6)
[23]

QUESTION 4

4.1 Empirical formula is the simplest whole number ratio of atoms in a compound ✓ Molecular formula is the exact formula of a molecule, giving the types of atoms and the number of ✓ each. (2)

4.2

Step 1: Convert % to mass
Assume 100 g of sample
$\therefore$ Carbon = 60,00 g
Hydrogen = 4,48 g
Oxygen = 35,52 g
} ✓

Step 2: Calculate number of moles for each atom
$n = \frac{m}{M}$ ✓

Carbon: $\frac{60{,}00}{12} = 5 mol$ ✓

Hydrogen: $\frac{4{,}48}{1} = 4{,}48 mol$ ✓

Oxygen: $\frac{35{,}52}{16{,}00} = 2{,}220 mol$ ✓

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Step 3: Divide by smallest number of moles

Carbon: $\frac{5}{2,220} = 2,25$

Hydrogen: $\frac{4,48}{2,220} = 2,018$ ✓

Oxygen: $\frac{2,220}{2,220} = 1,00$

Step 4: Multiply each ratio by 4

Carbon	Hydrogen	Oxygen
2,25 x 4 = 9	2,018 x 4 = 8,072 = 8	1 x 4 = 4 ✓✓

Step 5 Empirical formula: $C_9H_8O_4$ ✓

(9)

4.3 $\frac{\text{Molecular formula mass}}{\text{Empirical formula mass}} = \frac{540}{(12x9)+(1x8)+(16x4)}$ ✓

$= 3$

Molecular formula = $C_{27}H_{24}O_{12}$ ✓ (2)

[13]

QUESTION 5

5.1.1 Iron was in excess, ✓ so it did not completely react with the sulphur. Iron is magnetic ✓ (2)

5.1.2 Using sulphur since it is a limiting reagent ✓
1 mol sulphur producer 1 mol FeS ✓
32 g sulphur produces 87,85 FeS ✓
25 g sulphur produces $\frac{87,85 \times 2,5g}{32}$ FeS ✓✓
$= 6,86$ g FeS ✓

(6)

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5.2 3 mol Carbon ⟶ 1 mol CaC_2 ✓
3 x 12 kg carbon ⟶ 1 x 64 kg CaC_2 ✓
1,5 kg carbon ⟶ $\frac{1,5 \times 64kg}{3x\ 12}$ CaC_2 ✓
$= 2,67$ kg CaC_2 ✓

∴ Theoretical yield $= 2,67$ kg CaC_2

% yield CaC_2 $= \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$ ✓

$= \frac{2,42}{2,67} \times 100$ ✓✓

$= 90,64\%$ ✓ (8)

5.3 RM:ZnS: $65 + 32 = 97$

% Zn in ZnS $= \frac{65}{97} \times 100$ ✓ ✓

$= 67,01\%$ ✓

100% ZnS = 67,01% Zn
x ZnS = 40,50% Zn ✓
x $= \frac{40,50}{67,01} \times 100$ ✓
$= 60,44\%$ ✓ (6)

[22]

QUESTION 6

6.1 ✓
$n = \frac{m}{M} = \frac{20,8}{208} = 0,10 mol$ ✓ ✓
$c = \frac{n}{V} = \frac{0,10}{0,25} = 0,40 mol.dm^{-3}$ ✓

OR

$C = \frac{m}{MV} = \frac{20,4}{208 \times 0,25} = 0,40 moldm^{-3}$ ✓ ✓ ✓ ✓

(5)

6.3 $[Cl^-] = 2 \times [BaCl_2]$
$= 2 \times 0,40$ ✓
$= 0,80\ mol.dm^{-3}$ ✓ (2)

6.4 $C_1V_1 = C_2V_2$ ✓
$0,40 \times 100 = 0,1 \times V_2$ ✓
$400\ cm^3 = V_2$ ✓
Water to be added = 400 – 100 ✓ = 300 cm^3 ✓ (5)

[12]

TOTAL: [100]

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