10/10 30/30 (This time!)

Chemistry HL 2018-2020
Bonding test.

Time Allowed : 55 mins

Name: Jerry Jiang

Part A: Circle the correct answer

1. How many atoms are present in 0.10 mol of $PtCl_2(NH_3)_2$?

1.1 mol / 6.02×10^{23}

A. 6.0×10^{22}

B. 3.0×10^{23}

(C.) 6.6×10^{23}

D. 6.6×10^{24}

0.05 mol

2. What mass of carbon dioxide, $CO_2(g)$, in g, is produced when 5.0 g of calcium carbonate, $CaCO_3(s)$, reacts completely with hydrochloric acid, $HCl(aq)$?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

0.05 × 44 = 2.20

A. 0.050

(B.) 2.2

C. 4.4

D. 5.0

3. The volume occupied by one mole of an ideal gas at 273 K and 1.01×10^5 Pa is 22.4 $dm^3 mol^{-1}$. What volume of hydrogen, in dm^3, is produced when excess magnesium ribbon reacts with 100 cm^3 of 2.00 mol dm^{-3} hydrochloric acid?

0.1 × 2

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

0.1 mol

0.2 mol

A. 0.100

(B.) 2.24

C. 4.48

D. 22.4

(3)

4.

Which species will require the least energy for the removal of one electron?

A. Na^+ X

→ (B.) Mg^+

C. Al^{2+}

D. C^{3+} X

5.

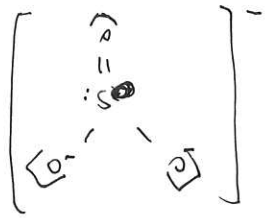
Which species has the same molecular geometry as SO_3^{2-}?

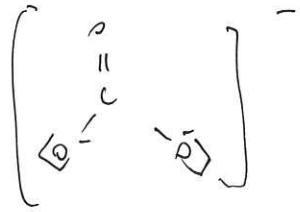
A. BF_3

B. SO_3

(C.) PF_3

D. CO_3^{2-} X

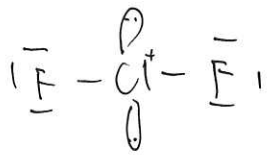




6.

How many lone pairs and bonding pairs of electrons surround the central chlorine atom in ClF_2^+?

	Lone pairs	Bonding pairs
A.	0	2
B.	0	4
C.	2	4
(D.)	2	2



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7.

Which is the best description of a metallic bond?

A. Electrostatic attraction between oppositely charged ions

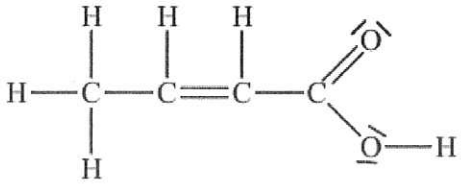
B. Electrostatic attraction between a pair of electrons and positively charged nuclei

C. Electrostatic attraction between a lattice of positive ions and delocalized electrons

D. Electrostatic attraction for a bonding pair of electrons which have been supplied by one of the atoms

8.

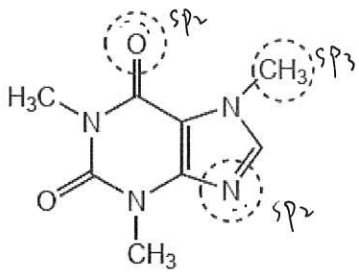
How many sigma (σ) and pi (π) bonds are there in the following molecule?



	σ bonds	π bonds
A.	9	2
B.	9	4
C.	11	2
D.	11	4

9.

What is the hybridization of the circled carbon, oxygen and nitrogen atoms?



	Carbon	Oxygen	Nitrogen
A.	sp^3	sp	sp
B.	sp^2	sp^2	sp
C.	sp^2	sp^3	sp^2
D.	sp^3	sp^2	sp^2

10.

What are the correct formulas of the following ions?

	Nitrate	Sulfate	Phosphate	Hydrogencarbonate
A.	NO_3^-	SO_4^{2-}	PO_4^{3-}	HCO_3^-
B.	NO_3^-	SO_4^{2-}	PO_3^{3-}	HCO_3^{2-}
C.	NO_2^-	SO_4^-	PO_4^{3-}	HCO_3^-
D.	NO_1^-	SO_3^{2-}	PO_3^{3-}	HCO_3^{2-}

2

Part B

1. A student decided to determine the molecular mass of a solid monoprotic acid, HA, by titrating a solution of a known mass of the acid.

The following recordings were made.

Mass of bottle / g ± 0.001 g	1.737
Mass of bottle + acid HA / g ± 0.001 g	2.412

(a) Calculate the mass of the acid and determine its absolute and percentage uncertainty. *[2]*

$m_{HA} = 2.412\text{g} - 1.737\text{g} = 0.675\text{ g}$

absolute uncertainty = $0.001\text{g} + 0.001\text{g} = 0.002\text{ g}$

percentage uncertainty = $0.002\text{g} \div 0.675\text{g} = 0.296\%$

2

(c) The percentage composition of HA is 70.56% carbon, 23.50% oxygen and 5.94% hydrogen. Determine its empirical formula. *[2]*

$n(C) = 70.56 \div 12.01 = 5.875$

$n(O) = 23.5 \div 16.00 = 1.47$

$n(H) = 5.94 \div 1.01 = 5.88$

C: $5.875 \div 1.47 \approx 4$

O: 1

H: $5.88 \div 1.47 \approx 4$

$\therefore C_4H_4O$

2

4

Phosphorus forms two chlorides, PCl_3 and PCl_5.

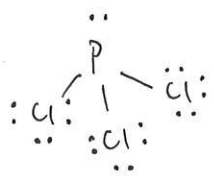
(i) Apply the Aufbau principle to state the **full** electron configuration for an atom of phosphorus. *[1]*

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$

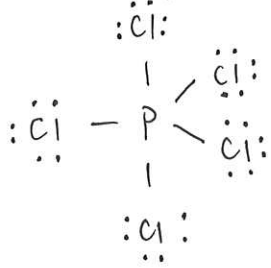
1

(ii) Deduce the Lewis structures for PCl_3 and PCl_5. *[2]*

PCl_3



PCl_5



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(iii) Predict the shapes and the bond angles in the two molecules. *[4]*

	PCl_3	**PCl_5**
Shape	trigonal pyramidal	trigonal bipyramidal
Bond angles	$\approx 107^\circ$	$Cl_{ax}PCl_{ax} = 180^\circ$ $Cl_{ax}PCl_{eq} = 90^\circ$ $Cl_{eq}PCl_{eq} = 120^\circ$

4

7

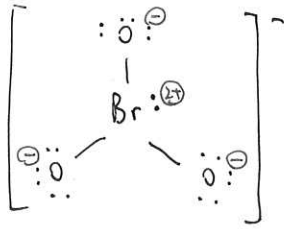
(iv) Identify the type of hybridization present in PCl_3. *[1]*

P: sp^3 hybridized
Cl: sp^3 hybridized

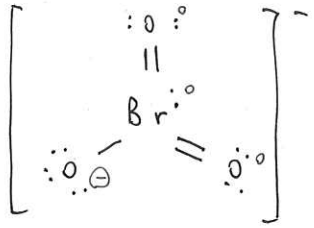
1

(b) (i) Draw two Lewis (electron dot) structures for BrO_3^-. [2]

Structure I – follows octet rule:



Structure II – does not follow octet rule:



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(ii) Determine the preferred Lewis structure based on the formal charge on the bromine atom, giving your reasons. [2]

According to the formal charged in blue above, structure one has formal charge of +2 for bromine atom, while in structure two, Br has 0 as formal charge. 0 as formal charge is preferred, so structure two is preferred.

PS: Also, the overall charge adds up to 5 units in Structure 1, but only 1 unit in structure 2. Furthermore, the negative charge in structure 2 is on oxygen, which is more electronegative, is preferred. These makes structure 2 preferred as well.

2

5

(c) Predict, using the VSEPR theory, the geometry of the BrO_3^- ion and the O–Br–O bond angles. [3]

Geometry:

trigonal pyramidal ✓

Reason:

4 charge centers forms tetrahedral frame work, but one center is lone electron pair, which exerts repulsion to the three other groups, forming trigonal pyramidal shape. ✓

O–Br–O angle:

≈ 107°. ✓

3

4. Properties of elements and their compounds can be related to the position of the elements in the periodic table.

(a) Explain the decrease in atomic radius from Na to Cl. [2]

$Z_{eff} = Z - S$. as period 3 develops, Z increase. although the shielding, screening and repulsion (S) increased as well, $\Delta Z > \Delta S$, making Z_{eff} increase. Thus, electrons are more and more attracting to the nucleus, presenting the decreasing trend in atomic radius.

2

(b) Explain why the radius of the sodium ion, Na^+, is smaller than the radius of the oxide ion, O^{2-}. [2]

Na^+ and O^{2-} have the same electron configuration, $1s^2 2s^2 2p^6$, so in $Z_{eff} = Z - S$, S is the same. However, Na^+ has high Z than O^{2-}, (~~more~~ stronger nuclear charge), make the Z_{eff} for Na^+ high than O^{2-}, so the ~~the~~ ionic radius of Na^+ is smaller.

meaning that electrons are more attracted in Na^+.

since Na^+ has 11 protons while O^{2-} has only 8.

2

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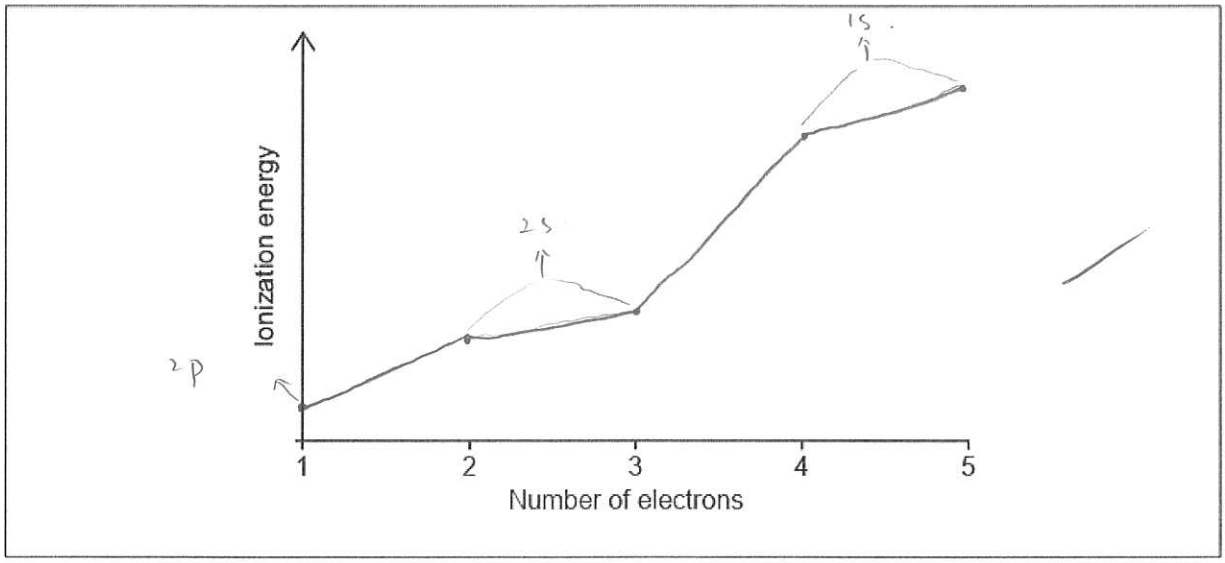
(c) Sketch a graph to show the relative values of the successive ionization energies of boron. [2]



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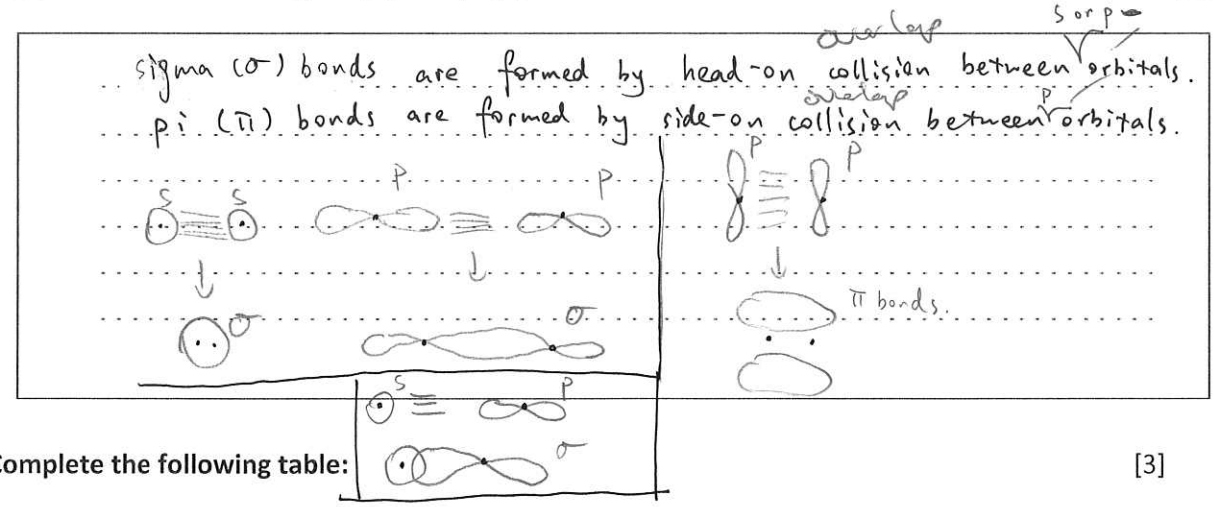
(ii) Describe how sigma (σ) and pi (π) bonds form. [2]

sigma (σ) bonds are formed by head-on overlap between s or p orbitals.
pi (π) bonds are formed by side-on overlap between p orbitals.



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Complete the following table: [3]

Type of Bonding	Strong Electrostatic Attraction between _____ and _____	
Covalent	two nucleis	shared pairs of electrons
Ionic	cations	anions.
Metallic	cations	electron sea of delocalised electrons

3