Chemistry HL 2018-2020
Atomic Structure test.

Time Allowed : 65 mins

Name: Jerry Jiang

10/10 25/28
35% 65%
95%

Part A: Circle the correct answer

1.

Which element is in the p-block?

(A.) Pb

B. Pm

C. Pt

D. Pu

2.

Which electron configuration is correct for the selenide ion, Se^{2-}?

A. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4d^{10}\ 4p^4$

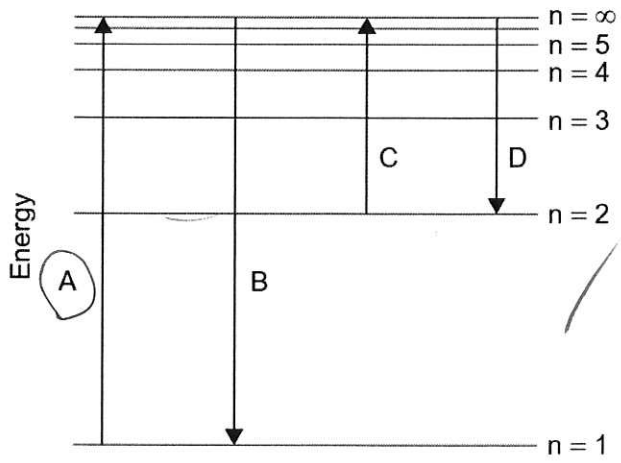
B. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 4d^{10}\ 4p^6$

C. $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^4$

(D.) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}\ 4p^6$ [Kr]

3.

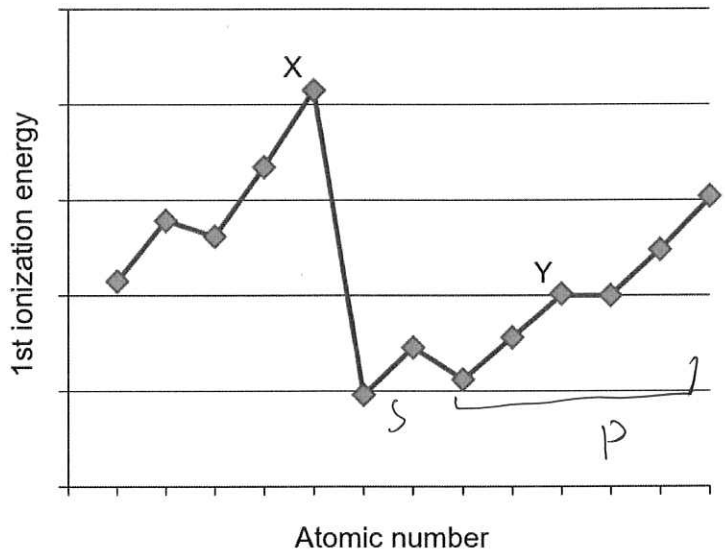
Which transition on the diagram corresponds to the ionization of hydrogen in the ground state?



3

4.

The graph shows the first ionization energies of some consecutive elements.



Which statement is correct?

A. Y is in group 3

B. Y is in group 10

C. X is in group 5

D. X is in group 18

Y : 15 / 5

X : 18 / 8

5.

What is the number of atoms of oxygen in 2.0 mol of hydrated sodium carbonate, $Na_2CO_3 \cdot 10H_2O$?
Avogadro's constant, L or N_A : $6.02 \times 10^{23}\,mol^{-1}$

A. 6

B. 26

C. 3.6×10^{24}

D. 1.6×10^{25}

13 mol 0 atom per mol

2 mol × 6.02×10^{23} =

~~15 6.5 × 10~~

1.6×10^{25}

2

6.

What is the molecular formula of a hydrocarbon containing 84.6% carbon by mass with a molar mass of 142.3 g mol^{-1}?

A. $C_{20}H_{44}$

B. $C_{11}H_{10}$

C. $C_{10}H_{22}$

D. C_5H_{11}

$\frac{84.6}{12} = 7.05$

15.4

$120 + 22 = 142$.

$15.4 : 7.05$

$7.05 \times 2.2 = 15.510$

7.

What is the percentage yield when 2.0 g of ethene, C_2H_4, is formed from 5.0 g of ethanol, C_2H_5OH?
M_r (ethene) = 28; M_r (ethanol) = 46

A. $\frac{2.0}{28} \times \frac{5.0}{46} \times 100$

B. $\frac{\frac{2.0}{28}}{\frac{5.0}{46}} \times 100$

C. $\frac{28}{2.0} \times \frac{5.0}{46} \times 100$

D. $\frac{\frac{28}{2.0}}{\frac{5.0}{46}} \times 100$

$C_2H_5OH \rightarrow C_2H_4 + H_2O$

$\frac{5.0}{46}$ $\frac{2.0}{28}$

$\frac{\frac{2.0}{28}}{\frac{5.0}{46}} \times 100 = \frac{2.0 \cdot 46}{5.0 \cdot 28} \cdot 100$

8.

What are the numbers of neutrons and electrons in the iodine ion, $^{125}I^+$?

	Neutrons	Electrons
A.	~~53~~	53
B.	72	52
C.	72	53
D.	~~125~~	52

$53 + 72 = 125$

52.

3

9.

Consider the relative abundance of the isotopes of element X.

Isotope	Relative abundance (%)
^{24}X	80
^{25}X	10
^{26}X	10

What is the relative atomic mass of X?

A. 24

B. 25

C. Between 24 and 25

D. Between 25 and 26

10.

Which ion will be deflected most in a mass spectrometer?

A. $^{16}O^{+}$

B. $^{16}O^{2+}$

C. $^{18}O^{+}$

D. $^{18}O^{2+}$

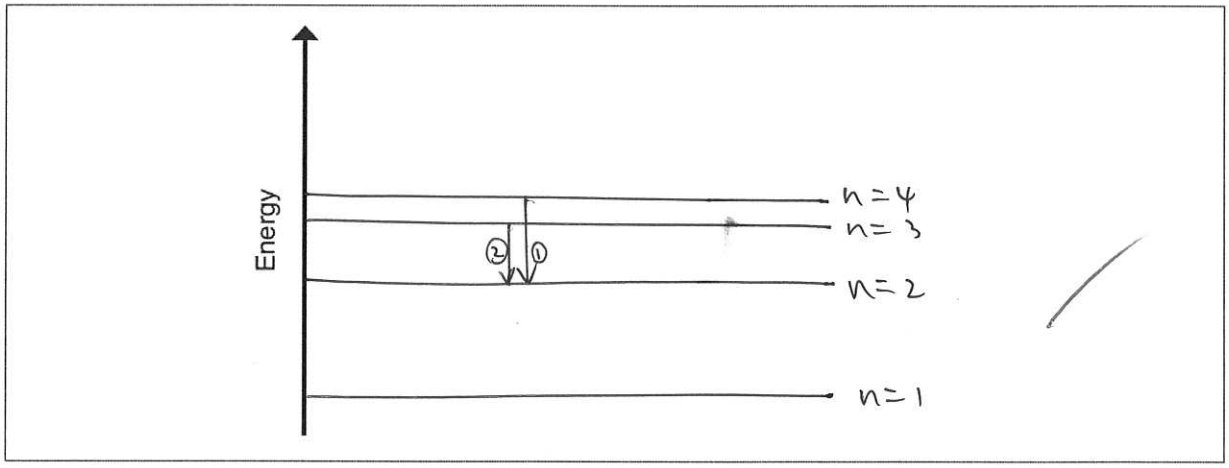
2

PART B

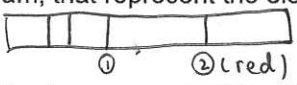
1.

The emission spectrum of an element can be used to identify it.

(a) (i) Draw the first four energy levels of a hydrogen atom on the axis, labelling n = 1, 2, 3 and 4. [1]



(ii) Draw the lines, on your diagram, that represent the electron transitions to n = 2 in the emission spectrum. [1]



← emission spectrum of hydrogen

(iii) Hydrogen spectral data give the frequency of $3.28 \times 10^{15} s^{-1}$ for its convergence limit.

Calculate the ionization energy, in J, for a single atom of hydrogen using sections 1 and 2 of the data booklet. [1]

$E = h\nu = 6.63 \times 10^{-34}\ J \cdot s \cdot 3.28 \times 10^{15}\ s^{-1}$

$= 2.17 \times 10^{-18}\ J$

(iv) Calculate the wavelength, in m, for the electron transition corresponding to the frequency in (a)(iii) using section 1 of the data booklet. [1]

$\lambda = \frac{c}{\nu} = \frac{3.00 \times 10^{8}\ m \cdot s^{-1}}{3.28 \times 10^{15}\ s^{-1}}$

$= 9.15 \times 10^{-8}\ m$

4

2. (a) (i)

A sample of magnesium has the following isotopic composition.

Isotope	^{24}Mg	^{25}Mg	^{26}Mg
Relative abundance / %	78.6	10.1	11.3

Calculate the relative atomic mass of magnesium based on this data, giving your answer to **two** decimal places. [2]

$A_r(Mg) = 24 \times 78.6\% + 25 \times 10.1\% + 26 \times 11.3\%$

$= 24.33$ ✓ 2

(ii) Explain why the second ionization energy is greater than the first ionization energy [2]

for magnesium

$Z_{eff} = Z - S$ When we compare the first and second IE, the nuclear charge (Z) is unchanged. However, when we remove the first electron, there's repulsion from the other electron that is count as (S); while when we are removing the second electron, it's the only one left in 3s, leading to smaller S and larger Z_{eff} compared to calculation of first I.E. Since Z_{eff} for 2nd IE is larger, it takes (a bit) more energy to accomplish. 2

(b)

Menthol is an organic compound containing carbon, hydrogen and oxygen.

(i) Complete combustion of 0.1595 g of menthol produces 0.4490 g of carbon dioxide and 0.1840 g of water. Determine the empirical formula of the compound showing your working. [3]

$n_{CO_2} = \frac{m}{M_{CO_2}} = \frac{0.4490\,g}{(12.01+2\times16.00)\,g/mol} = 0.01020\,mol \Rightarrow n_C = 0.01020\,mol$

$n_{H_2O} = \frac{m}{M_{H_2O}} = \frac{0.1840\,g}{(1.01\times2+16.00)\,g/mol} = 0.01021\,mol \Rightarrow n_H = 0.02042\,mol$ (×2)

$\therefore m_C = n_C \cdot M_C = 0.01020\,mol \cdot 12.01\,g/mol = 0.1225\,g$

$m_H = n_H \cdot M_H = 0.02042\,mol \cdot 1.01\,g/mol = 0.0206\,g$

$\therefore m_O = 0.1595\,g - 0.1225\,g - 0.0206\,g = 0.0164\,g$

$n_O = \frac{m}{M_O} = \frac{0.0164\,g}{16.00\,g/mol} = 0.00103\,mol$

$\therefore n_C : n_H : n_O = 0.01020\,mol : 0.02042\,mol : 0.00103\,mol$

$= \frac{0.01020}{0.00103} : \frac{0.02042}{0.00103} : 1$

$= 9.90 : 19.8 : 1$ 3

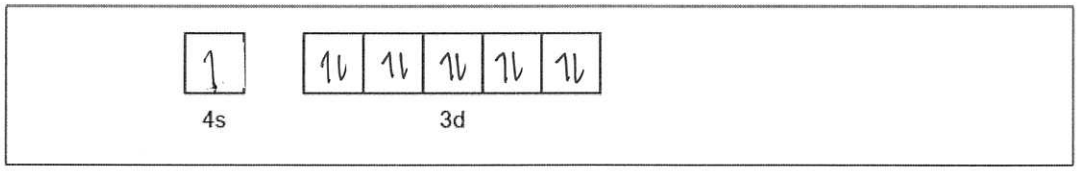
$\therefore$ empirical formula: $C_{10}H_{20}O$ ✓

7

3. (a)

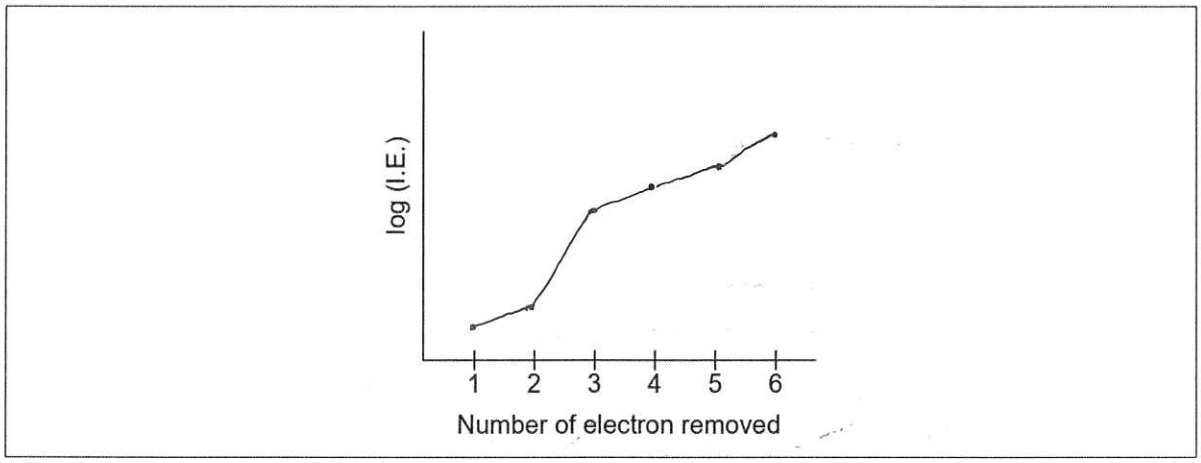
Copper is widely used as an electrical conductor.

Draw arrows in the boxes to represent the electronic configuration of copper in the 4s and 3d orbitals. [1]



1

(b) Sketch a graph of the first six ionization energies of calcium [2]



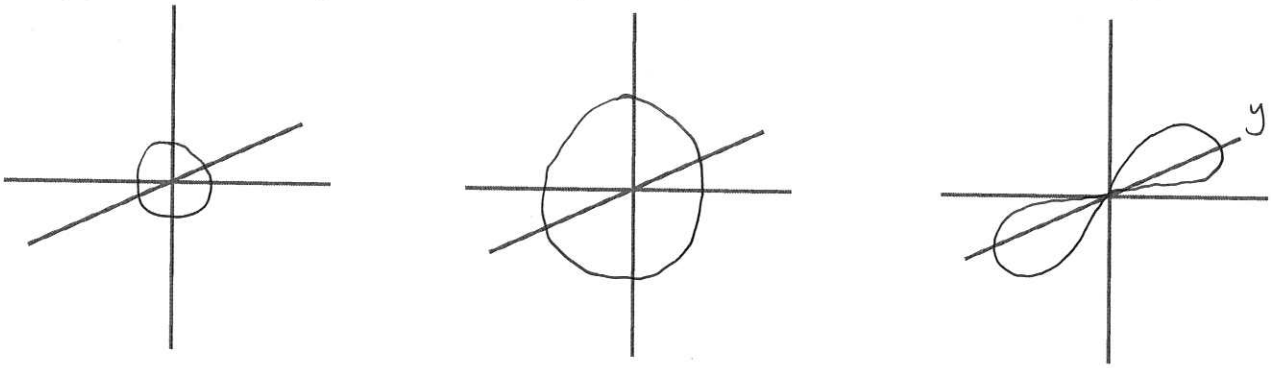
2

(c) (i) What is an orbital? [2]

It's the solution to the Schrodinger's Wave Equation.
It shows a region of space that electron has high probability to appear.

2

(ii) Draw the following orbitals on the axes provided; [3]



1s **2s** **$2p_y$**

3

8

4. (a) $\mathbf{x} = 2.35 \pm 0.12$ $\mathbf{y} = 12.75 \pm 0.07$ $\mathbf{z} = 159 \pm 2$

Calculate the values and associated uncertainties for the following operations;

(i) $\mathbf{y - x}$ [2]

$y - x = 12.75 - 2.35$

$= 10.40$

uncertainty $= 0.12 + 0.07 = 0.19$

$\therefore y - x = 10.40 \pm 0.19$ ✓

2

(ii) $\frac{z}{y}$ [4]

$\frac{z}{y} = \frac{159}{12.75} = 12.5$

uncertainty:

relative: $\frac{0.07}{12.75}$ ~~$= 0.005$~~ ; $\frac{2}{159}$ ~~$= 0.01$~~

~~$0.005 + 0.01 = 0.015$~~ ⟹

$12.5 \times \left(\frac{0.07}{12.75} + \frac{2}{159}\right) = 0.225 \Rightarrow 0.23$

$\therefore \frac{z}{y} = 12.5 \pm 0.23$

$\therefore 12.50 \pm 0.23$ ✓

absolute: ~~$\therefore 12.5 \times 0.015 = 0.1875 = 0.18$~~

~~$\therefore \frac{z}{y} = 12.5 \pm 0.18 = 12.50 \pm 0.18$~~ 3 and 30 rule

4

(b) A chemistry student presented the following values and uncertainties for their calculated results in their IA. Identify which of these are incorrect and then write the correct value and uncertainty below. [3]

(i) 0.05 ± 0.0234 ✗

0.0509 ± 0.0234

0.050 ± 0.023

3 & 30 rule ...

(ii) 1.68744 ± 0.9 ✗

~~1.68~~

1.7 ± 0.9 ✓

(iii) $(3.12 \pm 0.94) \times 10^{-3}$ ✓

I think this is correct, but it seems more natural to be this way:

0.00312 ± 0.00094

0.0031 ± 0.0009

1

此处 calculation 默认乘除法，所以...

太 tm 无厘头了!!!

7