

ACDA 4011 CHEMISTRY (OME)

QUIZ #1

17. 02. 2022

ATOMIC STRUCTURE & ELECTRONIC CONFIGURATION

STUDENT'S NAME _____ **ANSWERS** _____

USEFUL CONSTANTS:

$$h = 6.63 \times 10^{-34} \text{ Js}$$

$$R_h = 3.29 \times 10^{15} \text{ s}^{-1}$$

$$c = 3 \times 10^8 \text{ m/s}$$

Question 1 (5p)

- A) Calculate the wavelength of a photon when the hydrogen atom undergoes a transition from $n = 4$ to $n = 2$.

$$c = \lambda \times \nu \text{ so } \lambda = \frac{c}{\nu} \text{ and}$$

$$\nu = R_h \times \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) = 3.29 \times 10^{15} \times \left(\frac{1}{4^2} - \frac{1}{2^2} \right) = 6.17 \times 10^{14} \text{ s}^{-1}$$

(absolute value as frequency cannot be negative)

$$\lambda = \frac{6.17 \times 10^{14} \text{ s}^{-1}}{3.00 \times 10^8 \text{ m/s}} = 4.86 \times 10^{-7} \text{ m} = 486 \text{ nm}$$

- B) What is the energy of this photon?

$$E = h \times \nu = 6.63 \times 10^{-34} \text{ Js} \times 6.17 \times 10^{14} \text{ s}^{-1} = 4.09 \times 10^{-19} \text{ J}$$

- C) Is the energy absorbed or emitted?

Energy is emitted as the electron moves from higher energy level to lower.

Question 2 (5p)

A) Write the full and shorthand electron configuration for Cr atom.

Atomic number of Cr is 24 so there are 24 protons and 24 electrons in each chromium atom in ground state.

full electron configuration would be $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^4$ BUT because half-filled subshell is more energetically favoured, the actual electron configuration for chromium atom is: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$

shorthand configuration is $[Ar] 4s^1 3d^5$

B) How many unpaired electrons are there? Support your answer with the orbital diagrams.

There are 6 unpaired electrons 

C) What will be the valence electron configuration for chromium ion which lost 3 electrons?

Chromium atom that lost 3 electrons forms Cr 3+ cation and has three electrons less than chromium atom in ground state. There are 21 electrons.

$1s^2 2s^2 2p^6 3s^2 3p^6 3d^3$ OR $[Ar] 3d^3$

Question 3 (5p)

A) How many protons, neutrons and electrons, respectively, are there in chloride ion, Cl^- ?

atomic number for chlorine atom is 17 so there are **17 protons**

it is chloride ion, Cl^- so there is one extra electron giving **18 electrons**

mass number (number of protons and neutrons) is 35 so **18 neutrons**

B) Using two isotopes of chlorine, $Cl-35$ and $Cl-37$, and their abundances, 75% and 25%, respectively, explain why the average atomic mass of chlorine atom is 35.5 and not 36.

Average mass of chlorine atom is related to the mass of each isotope and its abundance.

Question 4 (5p)

A) Give the formula of

a. Aluminium Sulphate $Al_2(SO_4)_3$

b. Ammonium Phosphate $(NH_4)_3PO_4$

B) What is the name of:

a. $Cu(HCO_3)_2$ copper hydrogen carbonate or copper bicarbonate

b. P_4S_6 tetraphosphorus hexasulfide

REFERENCE SHEET FOR ACDA4011 CHEMISTRY QUIZ #2

ANSWERS

PERIODIC CHART OF THE ELEMENTS																		INERT GASES			
IA	IIA	IIIB	IVB	VB	VIB	VIIIB	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA							
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11 Na 22.9898	12 Mg 24.312															13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80				
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Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
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90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)
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PHYSICAL CONSTANTS:

$c = 3.0 \times 10^8$ m/s (speed of light)
 $R_H = 3.29 \times 10^{15} \text{ s}^{-1}$ (Rydberg constant)
 $h = 6.6 \times 10^{-34}$ Js (Planck's constant)
 $e = 1.602 \times 10^{-19}$ C (charge of electron)
 $1 \text{ amu} = 1.66 \times 10^{-24}$ kg (atomic mass unit)
 6.02×10^{23} Avogadro's number
 $R = 0.0821 \text{ L-atm/mol-K}$

USEFUL EQUATIONS:

$g = n \times MM$
 $M = \text{mol} / v$
 $m = \text{mol of solute} / \text{kg solvent}$
 $\chi = (\text{moles of solute}) / (\text{total number of moles})$
 $c = v \times \lambda$
 $E = h \times v$
 $v = R_H ((1/n_1^2) - (1/n_2^2))$
 $\% \text{ yield} = (\text{actual yield} / \text{theoretical yield}) \times 100\%$

ACDA4011 CHEMISTRY QUIZ 2

NAME _____ DATE: March 24, 2022

1. (10 points) Indicate whether each of the following statements is true or false:

T F

___ ✓ A C-C single bond is generally shorter than a C=C double bond.

___ ✓ A lone pair is defined as a pair of electrons on the central atom.

___ ✓ According to VSEPR, molecules adjust their shape to keep inner shell electrons away as far as possible.

___ ✓ A bond where electrons are not shared equally is a nonpolar bond.

✓ ___ Covalent bond forms when the atom shares an electron with another atom.

___ ✓ If an atom gains one electron it will have +1 charge.

___ ✓ Atoms that have a high electronegativity give up their electron more easily.

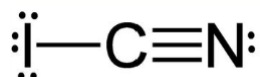
___ ✓ Ionisation energy increases across a period and increases down a group.

✓ ___ A chemical bond is formed to attain an octet state.

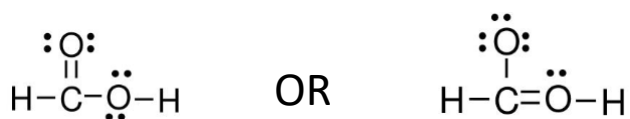
✓ ___ Molecule that has tetrahedral shape does not have lone pair(s) of electrons on the central atom.

2. (4 points) Draw the Lewis structure for the following molecules. Show all valence electrons:

A) ICN (C is the central atom)



B) HCO_2H (1 H is bonded to an oxygen, 1 H is bonded to carbon, both oxygens are bonded to carbon)



3. (6 points) For each of the following molecules, give the name of the molecular geometry and the shape, give an approximate value for the specified angle, and indicate whether the molecule has a permanent dipole. If an angle is a little smaller than some value, you must specify "greater than" or "less than" the closest angle you can name.

A) H_2S electron geometry ____ **tetrahedral** _____
shape ____ **bent** _____
H-S-H angle ____ **less than 109.5** _____
permanent dipole moment **Yes / No**

B) AsF_3 electron geometry ____ **tetrahedral** _____
shape ____ **trigonal pyramidal** _____
F-As-F angle ____ **less than 109.5** _____
permanent dipole moment **Yes / No**

REFERENCE SHEET FOR ACDA4011 CHEMISTRY QUIZ #3

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 $1 \text{ amu} = 1.66 \times 10^{-24}$ kg (atomic mass unit)
 $N_A = 6.02 \times 10^{23}$ Avogadro's number
 $R = 0.0821 \text{ L-atm/mol-K}$ gas constant

USEFUL EQUATIONS:

$g = n \times MM$
 $M = \text{mol} / v$
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ACDA4011 CHEMISTRY QUIZ 3

NAME _____ DATE: March 24, 2022

4. (5 points) Indicate whether each of the following statements is true or false:

T F

___ ☒ One mole of magnesium has the same number of atoms as one mole of hydrogen gas.

☒ ___ Molality of a solution does not change with temperature

___ ☒ A litre is a volume equal to 100 cm³.

___ ☒ When you make dilution the total moles of solute decrease.

___ ☒ The value of the mole fraction can be more than 1.

5. (2 points) Identify each of the following as an element, a compound, a homogeneous mixture or a heterogeneous mixture (no credit for "mixture" as the whole answer):

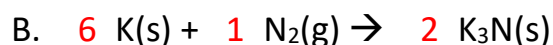
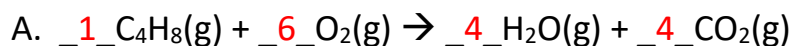
Stainless steel: homogenous mixture.....

Salsa Sauce: heterogenous mixture.....

An iron bar: element.....

Pure sodium chloride:.....compound.....

6. (3 points) Balance the following equations. Do not leave spaces blank. Write "1" to indicate a single unit of a species.



4. **(3 points)** How many nitrogen atoms are there in 30.0 g of N_2O_4 . Give your answer in individual atoms, not moles.

Molar mass of $N_2O_4 = 2 \times 14 + 4 \times 16 = 92 \text{ g/mol}$

30.0 g of N_2O_4 correspond to $30.0 \text{ g} / 92 \text{ g/mol} = 0.33 \text{ mol}$ of N_2O_4

In 1 mol of N_2O_4 there are 2 moles of N atoms, so in 0.33 mol of N_2O_4 there are $0.33 \text{ mol } N_2O_4 \times (2 \text{ mol N} / 1 \text{ mol } N_2O_4) = 0.66 \text{ mol N}$

Each mol of N atoms provides 6.022×10^{23} N atoms, so 0.66 mol N will provide $(0.66 \text{ mol N} \times 6.022 \times 10^{23} \text{ N atoms} / 1 \text{ mol N}) = \mathbf{3.93 \times 10^{23} \text{ N atoms}}$

$$30.0 \text{ g } N_2O_4 \times \frac{1 \text{ mol } N_2O_4}{92 \text{ g } N_2O_4} \times \frac{2 \text{ mol N}}{1 \text{ mol } N_2O_4} \times \frac{6.022 \times 10^{23} \text{ N atoms}}{1 \text{ mol N}} = \mathbf{3.93 \times 10^{23} \text{ N atoms}}$$

5. **(4 points)** 1.07g of solid $Ca(NO_3)_2$ are dissolved in enough water to make 452.1 mL of solution. Calculate the molar concentration of $Ca(NO_3)_2$ in such a solution.

Molar mass of $Ca(NO_3)_2 = 40.0 + 2 \times 14 + 6 \times 16 = 164 \text{ g/mol}$

1.07 g of $Ca(NO_3)_2$ correspond to $1.07 \text{ g} / 164 \text{ g/mol} = 0.0065 \text{ mol}$ of $Ca(NO_3)_2$

Molarity = mol solute/volume of solution [mol/L]

$M = 0.0065 \text{ mol } Ca(NO_3)_2 / 0.452 \text{ L} = \mathbf{0.0144 \text{ mol/L}}$

6. **(4 points)** Calculate the volume of 1.58 M NaOH solution that must be diluted with water to prepare 550 mL of 0.35 M solution.

Before dilution: $M_{\text{before}} = 1.58 \text{ M}$, $V_{\text{before}} = ?$

After dilution: $M_{\text{after}} = 0.35 \text{ M}$, $V_{\text{after}} = 550 \text{ mL}$

In dilution problems, number of moles of solute remain the same before and after dilution, $\text{mol}_{\text{before}} = \text{mol}_{\text{after}}$

Number of moles is related to the molarity via $M = \text{mol}/\text{volume}$

Molarity before the dilution is $M_{\text{before}} = \text{mol}/\text{volume}_{\text{before}}$, so mol of solute = $M_{\text{before}} \times V_{\text{before}}$

Molarity after the dilution is $M_{\text{after}} = \text{mol}/\text{volume}_{\text{after}}$, so mol of solute = $M_{\text{after}} \times V_{\text{after}}$

If $\text{mol}_{\text{before}} = \text{mol}_{\text{after}}$, $M_{\text{before}} \times V_{\text{before}} = M_{\text{after}} \times V_{\text{after}}$ SO $V_{\text{before}} = (M_{\text{after}} \times V_{\text{after}}) / M_{\text{before}}$

$V_{\text{before}} = (0.35 \text{ M} \times 550 \text{ mL}) / 1.58 \text{ M} = \mathbf{122 \text{ mL}}$

REFERENCE SHEET FOR ACDA4011 CHEMISTRY QUIZ #4

ANSWERS

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 $N_A = 6.02 \times 10^{23}$ Avogadro's number
 $R = 0.0821 \text{ L-atm/mol-K}$ gas constant

1 atm = 101.3 kPa = 101,325 Pa = 760 mm Hg = 760 torr = 14.7 lb/in² (psi)

USEFUL EQUATIONS:

$g = n \times MM$
 $M = \text{mol} / v$
 $m = \text{mol of solute} / \text{kg solvent}$
 $\chi = (\text{moles of solute}) / (\text{total number of moles})$
 $Pv = nRT$

ACDA4011 CHEMISTRY QUIZ 4

NAME _____ DATE: March 25, 2022

7. (10 points) Indicate whether each of the following statements is true or false:

T F

___ ✓ Gases have no definite shape but a definite volume.

✓ ___ Barometer is a device used to measure barometric pressure.

✓ ___ The pressure will increase when the volume of ideal gas decreases at a constant temperature.

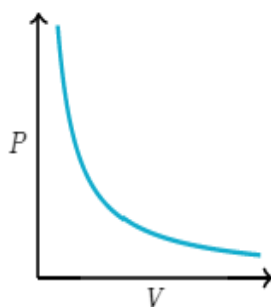
✓ ___ On a cold morning the car tires will have lower pressure.

___ ✓ For an ideal gas at constant pressure halving the temperature would halve the volume.

___ ✓ In STP the value of temperature is 298 K.

___ ✓ Temperature of 0 K corresponds to 298 degC.

✓ ___ Assuming constant n and T , the relationship between P and V is represented by the graph below.



___ ✓ One mole of hydrogen gas will occupy a larger volume than one mole of argon gas at the same T and P .

✓ ___ Molar mass of unknown gas can be calculated from the ideal gas equation.

2..(2 points) Calculate the pressure (in Pa) required to convert 0.25 dm³ of gas at 1.01325 × 10⁵ Pa (1 atm) into a volume of 0.1 dm³ at constant temperature?

Boyle's law: P is inversely proportional to V (when v goes down, P goes up)

To show this relationship an initial pressure must be multiplied by the correct factor

$$1.01325 \times 10^5 \text{ Pa} \times \frac{0.25 \text{ dm}^3}{0.1 \text{ dm}^3} = 2.53312 \times 10^5 \text{ Pa}$$

3. (3 points) A 28.0 L gas cylinder at 5.2 atm and 23 °C contains only carbon monoxide gas. What is the mass (in kg) of carbon monoxide in the tank?.

P = 5.02 atm, V = 28.0 L, R = 0.0821 atm-L/mol-K, T = 23 °C = 296 K

$Pv = nRT \rightarrow n = Pv / RT$

$n = (5.02 \text{ atm} \times 28.0 \text{ L}) / (0.0821 \text{ atm-L/mol-K} \times 296 \text{ K})$

n = 5.78 mol CO

1 mol of CO has mass of 28 g, 5.78 mol will have mass of (2.78 mol CO x 28 g/mol) **161 g CO**

4. (3 points) A 5.2 L gas cylinder containing 822 g of neon is heated until the pressure reaches 176,000 mmHg. What is the temperature in °C of the gas?

For Ne gas:

V = 5.2 L, m = 822 g, (MM = 20 g/mol $\rightarrow$ 822 g / 20 g/mol = 41.1 mol Ne),

P = 176,000 mmHg x (1 atm / 760 mmHg) = 232 atm, R = 0.0821 atm-L/mol-K

$Pv = nRT \rightarrow T = Pv / nR = (232 \text{ atm} \times 5.2 \text{ L}) / (41.1 \text{ mol} \times 0.0821 \text{ atm-L/mol-K})$

T = 357 K – 273 = **84 degC**

5. (2 points) Calculate the molar volume of one mole of an ideal gas under conditions of standard ambient pressure and temperature.

SATP: T= 25 degC = 298 K, P = 1 atm

n = 1 mol, R = 0.0821 atm-L/mol-K

$Pv = nRT \rightarrow v = nRT / P = (1 \text{ mol} \times R = 0.0821 \text{ atm-L/mol-K} \times 298 \text{ K}) / 1 \text{ atm}$

V = 24.4 L

REFERENCE SHEET FOR ACDA4011 CHEMISTRY QUIZ #5

ANSWERS

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3 Li 6.939	4 Be 9.0122															5 B 10.811	6 C 12.0112	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.183
11 Na 22.9898	12 Mg 24.312															13 Al 26.9815	14 Si 28.086	15 P 30.9738	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.9380	26 Fe 55.847	27 Co 58.9332	28 Ni 58.71	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.9216	34 Se 78.96	35 Br 79.909	36 Kr 83.80				
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (99)	44 Ru 101.07	45 Rh 102.905	46 Pd 106.4	47 Ag 107.870	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.904	54 Xe 131.30				
55 Cs 132.905	56 Ba 137.34	*57 La 138.91	72 Hf 178.49	73 Ta 180.948	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.967	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.980	84 Po (210)	85 At (210)	86 Rn (222)				
87 Fr (223)	88 Ra (226)	*89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (262)	108 Hs (265)	109 Mt (266)	110 ? (271)	111 ? (272)	112 ? (277)										

Numbers in parenthesis are mass numbers of most stable or most common isotope.

Atomic weights corrected to conform to the 1963 values of the Commission on Atomic Weights.

The group designations used here are the former Chemical Abstract Service numbers.

* Lanthanide Series

58 Ce 140.12	59 Pr 140.907	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.924	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.97
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† Actinide Series

90 Th 232.038	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (256)	103 Lr (257)
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PHYSICAL CONSTANTS:

$c = 3.0 \times 10^8 \text{ m/s}$ (speed of light)
 $R_H = 3.29 \times 10^{15} \text{ s}^{-1}$ (Rydberg constant)
 $h = 6.6 \times 10^{-34} \text{ Js}$ (Plank's constant)
 $e = 1.602 \times 10^{-19} \text{ C}$ (charge of electron)
 $1 \text{ amu} = 1.66 \times 10^{-24} \text{ kg}$ (atomic mass unit)
 $N_A = 6.02 \times 10^{23}$ Avogadro's number
 $R = 0.0821 \text{ L-atm/mol-K}$ gas constant

1 atm = 101.3 kPa = 101,325 Pa = 760 mm Hg = 760 torr = 14.7 lb/in² (psi)

USEFUL EQUATIONS:

$g = n \times MM$
 $M = \text{mol} / v$
 $m = \text{mol of solute} / \text{kg solvent}$
 $\chi = (\text{moles of solute}) / (\text{total number of moles})$
 $Pv = nRT$

ACDA4011 CHEMISTRY QUIZ 5

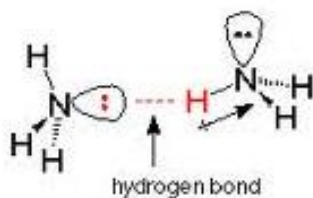
NAME _____ DATE: March 31, 2022

8. (10 points) Indicate whether each of the following statements is true or false:

T F

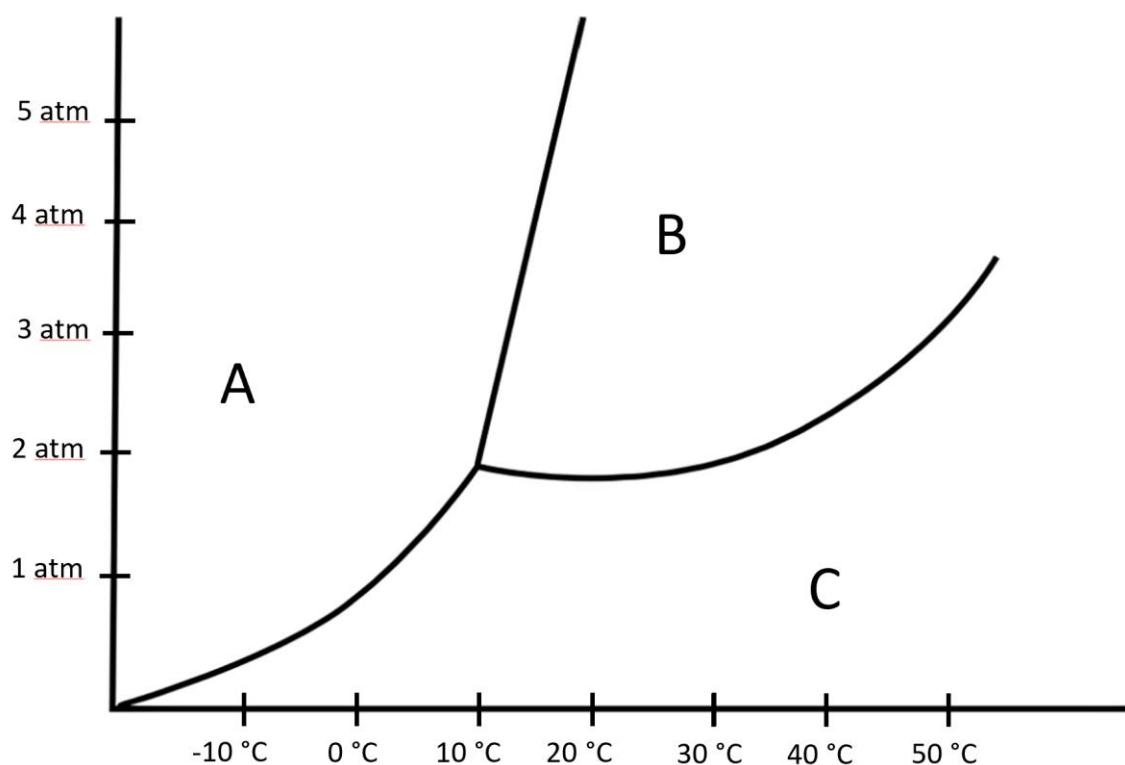
- ☐ ☒ Metallic bond is an example of interparticle force.
- ☐ ☒ Graphite and quartz are two allotropes of carbon.
- ☐ ☒ Intermolecular forces present in a Cl_2 are of dipole-dipole kind.
- ☐ ☒ CH_4 molecules can form hydrogen bonds.
- ☐ ☒ Polarizability decreases when the size of the molecule increases
- ☐ ☒ All metals have extremely high melting points.
- ☒ ☐ At the triple point solid, liquid and gas are in equilibrium.
- ☐ ☒ Sublimation and condensation are opposite processes.
- ☐ ☒ Solid ionic compounds can conduct electricity.
- ☒ ☐ H_2O molecules in the liquid phase are more closely packed than in the ice.

2..(2 points) In three sentences explain the formation of a hydrogen bond in NH_3 . You can draw a picture, too.



Hydrogen bond forms when the partial positive charge on one of the hydrogen atoms on one ammonia molecule interacts with the lone pair of electrons on nitrogen atom in the other ammonia molecule.

3. (6 points) For the phase diagram below



- Which area of the diagram, A, B or C, represents the liquid phase?**B**.....
- Which phase can exist at SATP?**gas**.....
- If a sample of this substance is cooled from 45 degC to 0 degC at a pressure of 3 atm, what phase change will occur?**deposition**.....
- What name is given to the change from phase C to phase B? ...**condensation**.....
- What are the boiling and freezing points of this substance at 3 atm?
.....**BP = 50 degC, FP = 10 degC**.....
- Estimate the conditions of a critical point**~4 atm and 52 degC**.....

3. **(3 points)** Which of the two halogen compounds, Cl_2 or Br_2 , is a liquid at room temperature? Explain your answer.

Br_2 is liquid at room temperature. Although both, Cl_2 and Br_2 are connected via London dispersion forces, Br_2 is larger than Cl_2 , more polarizable (squishable), and connected by stronger intermolecular forces which keep the molecules together in the liquid phase.

BONUS QUESTION: (1 point) A substance has the formula MCl_3 . It is a volatile liquid at room temperature, with a boiling point of 76 degC. What is the most likely formula? Why?

- a) ScCl_3
- b) PCl_3 the only non-metal chloride**
- c) AlCl_3
- d) AuCl_3

ACDA4011 CHEMISTRY QUIZ 6 ANSWERS

NAME _____ DATE: April 01, 2022

9. (10 points) Indicate whether each of the following statements is true or false:

T F

✓ ___ Redox reactions involve the transfer of electrons.

✓ ___ Substance that gains hydrogen is reduced.

✓ ___ In an uncharged compound, the sum of all the oxidation states is zero.

___ ✓ Oxidation number of oxygen is always -2.

✓ ___ High positive oxidation number (eg Cr +6) means that the species can be reduced easily.

___ ✓ Spectator ions undergo redox transition.

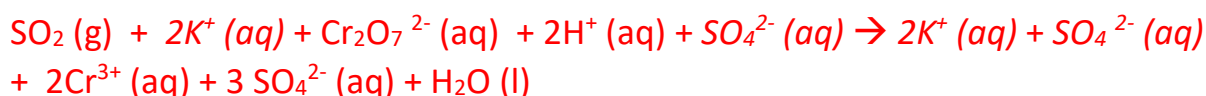
___ ✓ Excess of electrons in half equation is reduced by adding hydroxide ions.

___ ✓ Oxidation decreases the oxidation number of an element.

✓ ___ Reducing agent is oxidised in the redox process.

___ ✓ MnO_2 is reduced to MnO_4^- .

2..(2 points) Sulfur dioxide gas turns an acidified solution of potassium dichromate from orange to blue-green. The SO_2 forms SO_4^{2-} ions and $\text{Cr}_2\text{O}_7^{2-}$ forms Cr^{3+} ions. Write the chemical equation to demonstrate these changes. Use the method of half-reactions to identify reduction and oxidation and to balance the overall equation.



$2\text{K}^+ (\text{aq})$ and $\text{SO}_4^{2-} (\text{aq})$ are the spectator ions

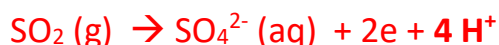
1. Balance 'important' atoms:



2. Electron balance:



3. Balance excessive negative charge with H^+



4. Balance excessive H^+ with water



5. Multiply OX half reaction by 3 so 6e are given away



6. Add half reactions together and regroup H^+ 's and waters

