

ACDA4011 CHEMISTRY OME (HNC) FINAL EXAM

NAME CHRISTOPHER BELTON DATE 30/11/22

SHOW ALL WORK. USE CORRECT UNITS AND SIGNIFICANT DIGITS. YOU MAY SHOW YOUR WORK ON THE BACK OF THE SHEET BUT INDICATE YOUR ANSWER ON THE FRONT.

PERIODIC TABLE AND REFERENCE DATA CAN BE TORN OFF OF THE EXAM

THERE ARE 10 QUESTIONS, 100 POINTS TOTAL (PLUS ANY EXTRA CREDIT EARNED IN THE CLASS). TIME 120 min

QUESTION 1:

For each of the following statements determine if it is **TRUE** or **FALSE**.

T F

✓ T ~~F~~ (2p) Multiple bonds are shorter and stronger than single bonds between the same atoms.

~~T~~ (2p) The elements in the periodic table are arranged in the order of increasing number of electrons.

✓ T ~~F~~ (2p) In 1 mole of water there are 6.02×10^{23} atoms of oxygen. *AVOGADRO'S NUMBER*

✓ ~~T~~ F (2p) Ideal gas equation describes well the behaviour of gases when the pressure and temperature of this gas tend to 0 atm and 0 K, respectively. *PV=nRT*

~~T~~ (2p) Activation energy of nitrocellulose and RDX is 86 kJ/mol and 199 kJ/mol, respectively. RDX is less stable than nitrocellulose.

✓ T (2p) The C₂H₄ molecule has six bonding electron pairs and no lone pairs.

✓ F (2p) For a hypothetical reaction $A + B \rightarrow C$ that is a second order in A, doubling the concentration of A will double the rate of the overall reaction.

✓ T (2p) All combustion reactions are exothermic.

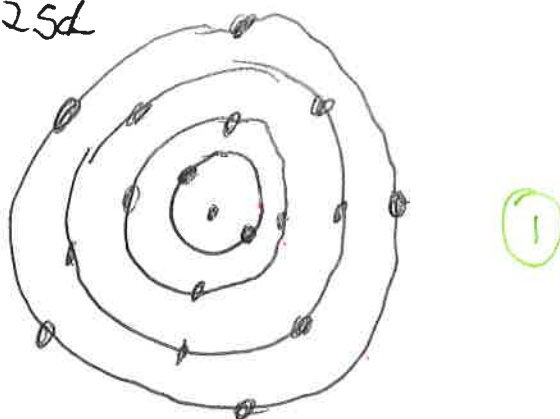
- ___ ~~F~~ (2p) Volume of gas produced in the detonation process decreases when the oxygen balance becomes less negative. more OX₂ = BETTER DETONATION
- ~~T~~ ___ (2p) The formula of potassium perchlorate is KClO₃.

QUESTION 2:

- a) (4p) Draw the Bohr model for a chlorine atom. Specify the number of orbits and indicate the position of all subatomic particles within the atom and their charges.

Start [Ne] ~~3s2s2p6~~
3s2s2d

17 ✓
CL
35.453 ✓



Comb 1s12p12s22p63s25d

- b) (3p) Give the definition of the term *Mass Number* and explain why for Cl atom the average atomic mass is 35.453.

CL - 35.453 IS THE ³MOLECULAR MASS FOR THE FOR CHLORINE
MOLECULAR MASS IS THE MOLECULAR WEIGHT OF ALL ATOMS (PROTON⁺, NEUTRONS, ELECTRONS)

c) (2p) How many protons and neutrons are there in chlorine-37?

PROTONS = POSITIVE CHARGE
NEUTRONS = NEUTRAL CHARGE

NO

0

17
CL
35.453

d) (2p) What will be the charge on chlorine atom when the outer shell is a complete octet?

THE CHARGE WILL BE NEGATIVE

1

QUESTION 3:

Many fireworks contain metal compounds that emit visible light. The colour given by calcium species at the wavelength of 616 nm is orange-red.

a) (3p) Calculate the energy of one photon of orange-red light emitted by calcium atom. Show your calculations.

$$E = h \times \nu$$

$$h = \text{PLANCK'S CONSTANT} = 6.6 \times 10^{-34}$$

$$E = 6.6 \times 10^{-34} \times 616 \text{ nm} = 208785$$

20
Ca
40.08

b) (3p) Write the full and shorthand electron configuration for calcium and show ALL the electrons in orbitals.

SHORT [Ar] 4s²

LONG 1s² 2s² 2p⁶ 3s² 3p⁶ 4s²

1p DOES NOT exist!!!



20
Ca
40.08

c) (3p) The colours seen in fireworks are a result of the emission of visible light. Explain how these colours are produced.

THESE COLOURS ARE PRODUCED BY CHASING A MATERIAL/COMPOUND THAT PRODUCES THE DESIRED COLOR WHEN REACTED. FOR EXAMPLE TO LUCH USE A STRONTIUM IF TO ~~REACT~~ REQUIRED A REA ~~COLOUR~~ FIREWORK, COMPOUNDS OR MIXTURES ARE ALSO USED FOR A MIXTURE OF COLOURS.

SULPHUR
SELENIUM
CHLORINE

QUESTION 4:

(4p) Consider only the three elements: S, Se, Cl.

a) Which one is most metallic?

Se ✓

(2)

b) Which one has the greatest electronegativity?

Cl ✓

↑ →

c) Which one has the highest ionisation energy?

S ✓

← ↑

d) Which one has the smallest atomic radius?

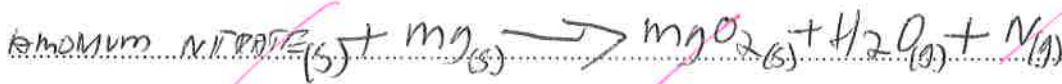
Se ✓

← ↓

QUESTION 5:

When ammonium nitrate and magnesium metal are mixed in a stoichiometric ratio, they form a pyrotechnic composition that decomposes to form magnesium oxide, water vapour and nitrogen gas.

a) (2p) Write a balanced equation showing all products for the decomposition of this mixture.



b) (2p) What percentage of magnesium, by mass, is contained in the stoichiometric mixture?

op

33% ?

c) (3p) Using the standard heats of formation listed below, calculate the heat of reaction for molar quantities of the reactants. Is this process exothermic or endothermic? Explain

Ammonium nitrate (solid) -365 kJ/mol

Magnesium oxide (solid) -601 kJ/mol

Water (gas) - 242 kJ/mol

op

HEAT OF REACTION =

THIS PROCESS IS EXOTHERMIC AS THE REACTION GIVES OFF HEAT.

how do you know that?

d) (3p) How does the heat of reaction from this reaction compare with 2.8 kJg^{-1} provided by one gram of TNT.

op
THIS IS AN EXOTHERMIC REACTION AND IS GREATER THAN THE PREVIOUS REACTION

QUESTION 6:

Some high explosives have the general formula $C_a H_b N_c O_d$. The oxidiser (O) and the fuel (C, H) are present in the same molecule. Nitrogen atoms are present, so there is a highly exothermic production of hot N_2 gas.

op
a) (4p) For an unknown explosive of general formula $C_a H_b N_c O_d$ and a molar mass of 152 g/mol , determine the coefficients a, b c and d if 152 g of this material decomposes to form 44.8 dm^3 of CO_2 , 44.8 dm^3 of H_2O , and 22.4 dm^3 of N_2 .



b) (2p) Which of the produced gases will move fastest and explain why?

NITROGEN WILL MOVE FASTEST DUE TO HAVING THE MOST ENERGY FROM THE REACTION.

6

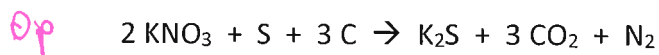
c) (3p) The oxygen balance of an explosive is the mass of oxygen either in excess (the balance is positive) or in deficit (the balance is negative) of that required for complete oxidation of C and H. The oxygen balance is expressed as a percentage of this oxygen weight over the molar mass of the explosive. Calculate the oxygen balance for explosive with the formula determined in part a).

OXYGEN BALANCE = $\frac{\text{WEIGHT}}{\text{MOLECULAR MASS}} \times 100$

6

QUESTION 7:

A simple chemical equation for the combustion of gun powder can be written as:



- a) (4p) Assuming that the reaction above can be carried out at STP, how many grams of CO_2 are formed from the decomposition of 45 g of KNO_3 ?

Handwritten solution for part a):

45g of KNO_3

$\text{K} = 39.1$
 $\text{N} = 14$
 $\text{O} = 16$

$\frac{45}{207.3} = 0.217 \text{ moles}$

$69.1 \times 3 = 207.3$

207.3 mass mass of KNO_3

0.5

- Op b) (4p) How many litres of gas products would form from the decomposition of 45 g of potassium nitrate at STP?

Handwritten solution for part b):

$PV = nRT$

$V = \frac{P \times n}{RT}$

0.5

Q4

c) (4p) 45 g KNO_3 at STP is heated to 100 degC and the pressure is reduced to 700 mmHg.

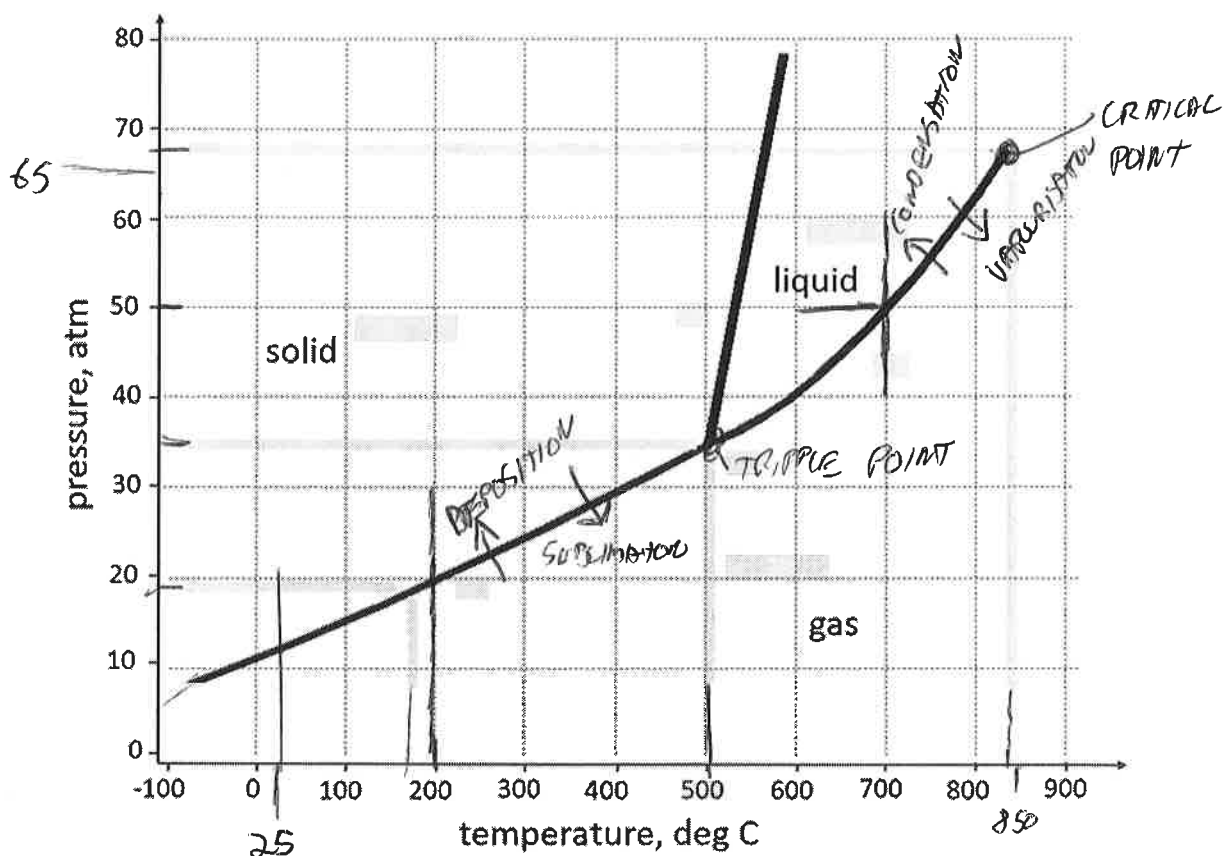
What is the new volume of the gases? Use the appropriate gas laws to support your answer.

$PV = nRT$



QUESTION 8:

The phase diagram of an unknown compound X, is shown below:



- a) (2p) What is the value of temperature and pressure at a critical point? What is the term used to describe the state of substance X above this point?

TEMP = 840 deg C PRESSURE = 67 atm

LIQUID IS THE TERM ~~FOR THE STATE~~ USED TO DESCRIBE SUBSTANCE X

- b) (2p) If you stored a bottle containing compound X on the work desk in the lab, what phase would it most likely be in?

LIKELY LAB CONDITIONS WOULD BE AROUND 20 deg C AND PRESSURE AROUND 1 atm? SO THE STATE WOULD BE GAS ✓

- c) (2p) If a sample of pure X is to be a mixture of liquid and gas, which point marks the sample's lowest possible temperature and pressure? Name all transitions occurring at this specific temperature and pressure.

LIQUID TO GAS = VAPORISATION

GAS TO LIQUID = CONDENSATION

500degC 35atm MARKS THE LOWEST TEMP + PRESSURE

①

- d) (2p) Can compound X be boiled at 200 deg C? Why?

NO BECAUSE IT IS NOT IN LIQUID FORM.

②

- e) (2p) What is the vapour pressure of substance X at 700 deg C?

50atm

③

- f) Does the melting point of X increase, decrease or stay the same as the pressure is increased?

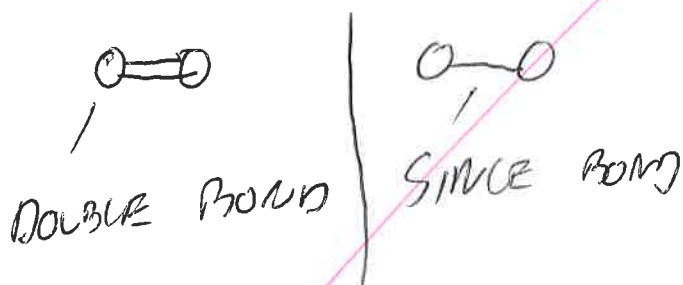
INCREASES DUE TO THE STATE OF X

②

QUESTION 9:

- 2p a) (4p) The normal boiling point is 100°C for H_2O and -33.3°C for NH_3 , even though the two molecules have almost identical atomic weights. Explain this difference in terms of intermolecular forces, using words or pictures, or both.

THE BOILING POINT CHANGES DUE TO THE STRENGTH OF THE BONDS ON THE MOLECULAR SCALE.



- 3p b) (3p) Give **ONE** specific example of how might water react to give undesirable performance from OME devices? Explain why. To answer this question, refer to your assignment.

RUST IS A VERY COMMON ISSUE FOUND IN OME DEVICES. WHEN THE MATERIAL RUSTS IT IS A REDOX REACTION TAKING PLACE. RUST CAN MAKE COMPONENTS THAT ARE DESIGNED TO COME APART SEIZE. ALSO IF ANY OF THE EXPLOSIVE MIXTURE HAS LEAKED INTO THE THREAD THIS COULD CAUSE DETONATION DUE TO THE IMPACT AND FRICTION ~~SENSITIVNESS~~ OF EXPLOSIVES. THIS ESPECIALLY TRUE ON OLDER MUNITION TYPES WHERE IM (INSENSITIVE MUNITIONS) HAVEN'T BEEN DEVELOPED YET WITH A WORRYING FIGURE OF INSENSITIVITY THAT HAVEN'T BE ACCEPTED BY MODERN STANDARDS.

QUESTION 10:

An explosive, RDX has an enthalpy of detonation of $-1106 \text{ kJ mol}^{-1}$.

- a) (3p) Sketch the reaction profile ("energy" vs. "progress of reaction") showing the reactants, products, activated complex, enthalpy of detonation and the activation energy



- b) (3p) (3p) Using the Arrhenius equation $k = A \exp(-E_a / RT)$ to support your answer, explain the relationship between activation energy, E_a , and the fraction of colliding molecules that result in a reaction.

$$k = A \exp(-E_a / RT)$$

$$k = A \exp \frac{-E_a}{RT}$$

$$E_a = \frac{k \times A \exp}{RT}$$

RT IS THE REACTANT EVERYTHING ABOVE IS DIVIDED BY THAT IS REACTED. THIS HAS A BIG IMPACT ON THE ENERGY

EXTRA CREDIT (if earned in class): 3 points

