

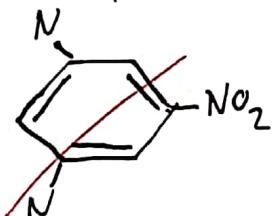
NAME Peter Down DATE: May 12, 2022

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 37 QUESTIONS, 100 POINTS TOTAL.

- 1p 1. (1p) An element with the valence electron configuration $3s^2 3p^4$ would most rapidly form an ion with what charge?

-2 ✓

- op 2. (2p) Draw two products of nitration of toluene.



- 2p 3. (3p) a) Give the total number of electrons in one NH_4^+ ion. (Count ALL the electrons, not just the valence electrons) 11

b) Give the number of protons in one NH_4^+ ion 11 ok

c) Give the number of nuclei in one NH_4^+ ion 5 nuclei ✓

- 3p 4. (3p) The valence electron configuration of Fe^{3+} ion is:

a) $3d^6 4s^2$

b) $3d^3 4s^2$

c) $3d^6$

d) $3d^5$ ✓

e) $3d^9 4s^2$

$4s^2 3d^6$ - 3 electrons

- 1.5p 5. (2p) State whether each of the following molecules has a dipole moment. (Four answers are required)

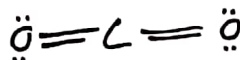
a) H_2S

(Yes) No



b) CO_2

Yes / (No)

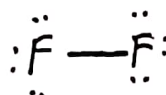


c) $\ddot{\text{O}}=\text{C}=\ddot{\text{S}}$

Yes / (No)

d) F_2

Yes / (No)



6. (1p) Which one of these orbitals does not exist:

a) 4p

b) 6s

c) 3f ✓

d) 5d

e) 2p

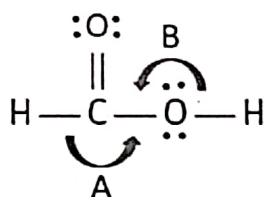
7. (3p) Classify the bonding in each of the following molecules as ionic, polar covalent, or non-polar covalent (no credit for the answer 'covalent').

a) H₂O Polar covalent ✓

b) N₂ Non polar covalent ✓

c) CaO Ionic ✓

8. (2p) In the molecule shown below, what is the value of the bond angle labelled A? What is the value of the bond angle labelled B?



angle A: 120°

angle B: 180°

9. (2p) Consider only the three elements: S, Se, Cl.

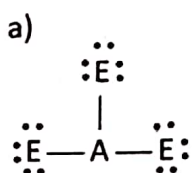
a) Which one is most metallic? Selenium

b) Which one has the greatest electronegativity? Chlorine

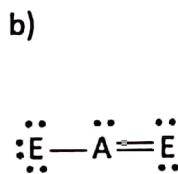
c) Which one has the highest ionisation energy? Sulfur

d) Which one has the smallest atomic radius? Sulfur ✓

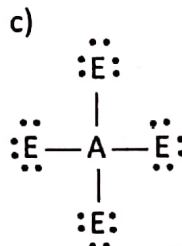
10. (4p) For each of the following molecules use words to describe its molecular shape (molecular geometry). Do not describe the electron pair geometry. Choose your answer from the following: linear, bent, square planar, trigonal planar, octahedral, trigonal pyramidal, square pyramidal, trigonal bipyramidal, T-shape, see-saw, tetrahedral, shapeless.



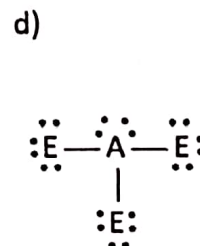
Trigonal planar ✓



Bent ✓



Trigonal pyramidal ✓



Trigonal bipyramidal ✓

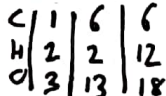
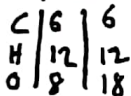
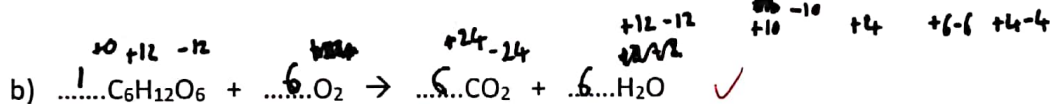
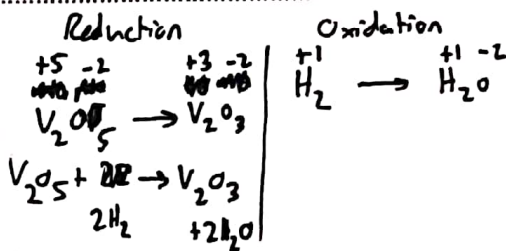
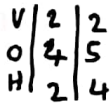
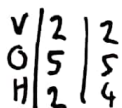
11. (4p) For each of the molecules in question 10 give the bond angle or angles. If the angle is a bit less than a certain value, you must state it.

- a) molecule a 120° ✓
 b) molecule b $< 120^\circ$ ✓
 c) molecule c 109° ✓
 d) molecule d $< 109^\circ$, 90°

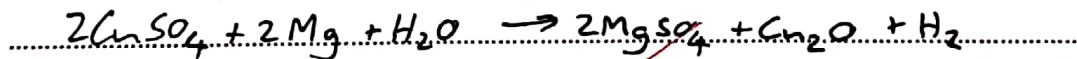
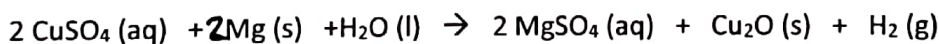
12. (2p) a) Circle the compound that has a higher boiling point, H_2O or H_2S .

b) Which kind of intermolecular force is responsible for the higher boiling point you picked in part (a)? Hydrogen bonding ✓

13. (4p) Complete and balance these reactions:



14. (1p) Find the net ionic reaction for the following process:



15. (2p) Consider only the following: 1) London dispersion attractions between two small molecules, 2) the O-H bond in a water molecule, 3) hydrogen bonding between two water molecules.

- a) Which one of the three is the strongest interaction? The OH bond 2) ✓
 b) Which one of the three is the weakest interaction? London dispersion 1) ✓

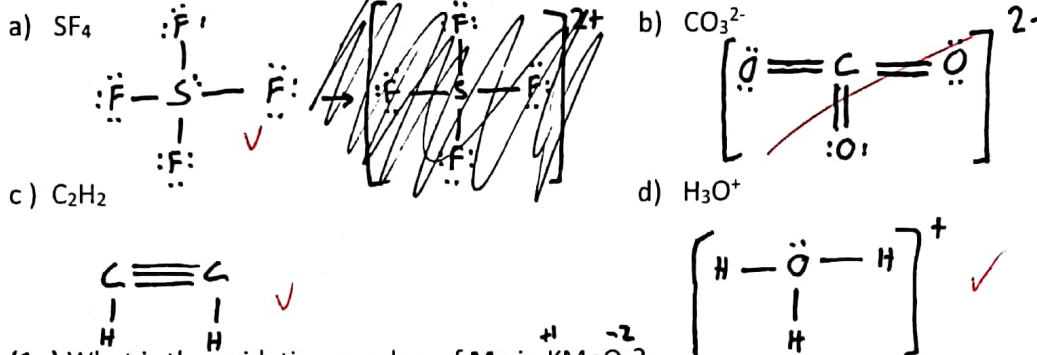
16. (1p) For which two gases are the rates of effusion 2:1?

- a) He and O_2 b) Ne and Kr
 c) N_2 and Ar d) H_2 and He
 e) O_2 and CH_4

17. (1p) Which process is endothermic:

- a) vaporisation ✓
 b) solidification
 c) condensation
 d) freezing
 e) all are exothermic

18. (6p) Draw the Lewis electron dot structure for each of the following:



19. (1p) What is the oxidation number of Mn in KMnO_4 ?

+7 ✓

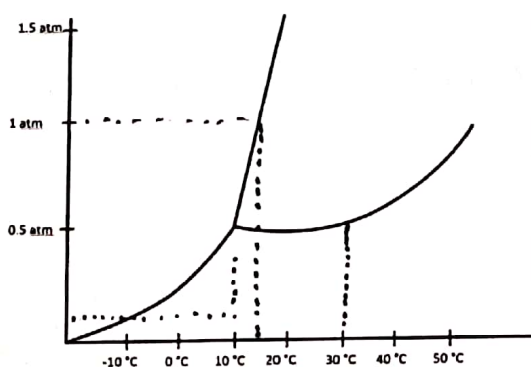
20. (4p) Give the formula of each of these:

- a) Magnesium bicarbonate..... $\text{Mg}(\text{HCO}_3)_2$ ✓
 b) Ammonium nitrate..... NH_4NO_3 ✓
 c) Silicone tetrabromide..... SiBr_4 ✓
 d) Copper (II) phosphate..... $\text{Cu}_3(\text{PO}_4)_2$ ✓

21. (2p) Name these:

- a) C_3O_2 Tricarbon dioxide ✓
 b) Ag_3N Gold nitride ✓

22. (4p) Consider the phase diagram for substance R:



- a) At 10 degC and 0.1 atm, is R a solid, a liquid or a gas? Gas ✓
 b) Does the melting point of R increase, decrease or stay the same as the pressure is increased? It increases ✓

- c) What is the vapour pressure of liquid R at 30 degC? 0.5 atm ✓
 d) What is the temperature of the normal boiling point of R? 15°C ✓

23. (3p) A student adds 20.0 mL of water to an empty graduated cylinder. Then she drops 65.0 g of a solid piece of metal into the water, and the level of the top of the water rises to 35.0 mL. Find the density of the metal.

- a) 4.33 g/cm³
 b) 1.86 g/cm³
 c) 3.25 g/cm³
 d) 1.18 g/cm³ ✓
 e) 0.231 g/cm³

24. (3p) An electron in a certain molecule has an energy of 2.0×10^{-18} J. If this electron emits a photon of frequency 8.0×10^{14} s⁻¹, find the new energy of the electron.

- a) 5.3×10^{-19} J
 b) 2.5×10^{-18} J ✓
 c) 6.4×10^{-18} J
 d) 1.1×10^{-19} J
 e) 6.0×10^{-23} J

$$\cancel{2 \times 10^{-18}} - \cancel{8 \times 10^{14}}$$

$$E = hf$$

$$= 6.63 \times 10^{-34} (8 \times 10^{14})$$

$$= 5.304 \times 10^{-19} \text{ J}$$

$$\text{Emits} \rightarrow (2 \times 10^{-18}) - (5.304 \times 10^{-19}) = 1.4696 \times 10^{-18} \text{ J}$$

$$\text{Absorbs} \rightarrow (2 \times 10^{-18}) + (5.304 \times 10^{-19}) = 2.5304 \times 10^{-18} \text{ J}$$

25. (3p) What mass of Zn (65.4 g/mol) will react with 280 mL of 3.00 M HCl (aq) according to the following equation: $\text{Zn (s)} + 2 \text{HCl (aq)} \rightarrow \text{ZnCl}_2 \text{ (aq)} + \text{H}_2 \text{ (g)}$.

- a) 86.2 g
 b) 54.9 g
 c) 40.1 g
 d) 27.5 g ✓
 e) 13.7 g

$$M = \frac{n}{V} \quad n = MV$$

$$= 3 (0.280)$$

$$= 0.84 \text{ mol HCl}$$

$$\frac{n_{\text{Zn}}}{0.84} = \frac{1}{2}$$

$$n_{\text{Zn}} = 0.42 \text{ mol Zn}$$

$$m = nMM$$

$$= 0.42 (65.4)$$

$$= 27.468 \text{ g}$$

26. (3pt) An ideal gas at T_1 300 K and P_1 2.00 atm pressure in a V_1 4000 cm³ container has its pressure increased to P_2 5.00 atm and its volume increased to V_2 6000 cm³. What is the final temperature T_2 ?

a) 80 K

b) 1125 K ✓

c) 640 K

d) 4500 K

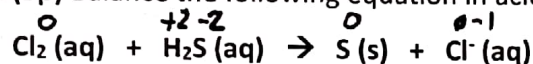
e) 820 K

$$PV = nRT$$

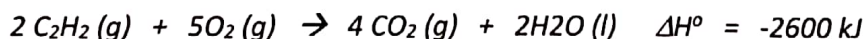
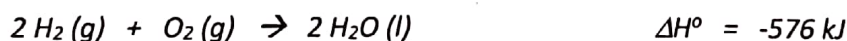
$$\frac{P_1 V_1}{n R T_1} = \frac{P_2 V_2}{n R T_2}$$

$$T_2 = \frac{P_2 V_2 T_1}{P_1 V_1} = \frac{5(6000)(300)}{2(4000)} = 1125 \text{ K}$$

27. (3p) Balance the following equation in acidic solution using the lowest possible integers.



28. (3p) Given these ΔH° values



Find ΔH° for $2\text{C}(\text{s}) + \text{H}_2(\text{g}) \rightarrow \text{C}_2\text{H}_2(\text{g})$.

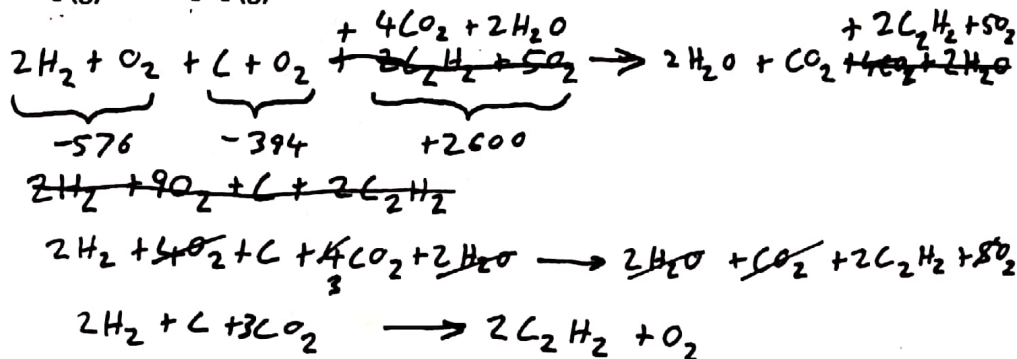
a) -3570 kJ

b) 812 kJ

c) 224 kJ

d) 1918 kJ

e) 465 kJ



29. (3p) Find the number of oxygen atoms in 25 g CO₂.

a) 2

b) 9.4 x 10⁻²⁵

c) 6.8 x 10²³ ✓

d) 5.3 x 10²⁴

e) 1.2 x 10²³

$$MM(CO_2) = 12 + 2(16) = 44$$

$$MM(O_2) = 32$$

$$n = \frac{25}{44} = 0.568 \text{ mol}$$

$$0.568 \text{ mol} (6.02 \times 10^{23}) = 3.42 \times 10^{23}$$

30. (3p) Determine the Celsius temperature of 2.49 moles of gas contained in a 1.0 L vessel at a pressure of 143 kPa.

a) -266 degC

b) -622 degC

c) 622 degC

d) 266 degC

e) 133 degC

$$PV = nRT$$

$$T = \frac{PV}{nR} = \frac{143(1)}{2.49(8.314)} = 6.908$$

$$6.908 - 273.15 = -266.24^\circ C$$

$$T = \frac{1.411(1)}{2.49(0.0821)} = 6.902^\circ K$$

$$6.902 + 273.15 = 280.05^\circ C$$

31. (3p) Find the mass of O₂ that will react with 22 g of C₃H₈ to form CO₂ and H₂O.

a) 20 g

b) 40 g

c) 80 g ✓

d) 120 g

e) 160 g



$$\begin{array}{c} \uparrow \quad \uparrow \\ 22g \quad MM = 3(12) + 8(1) \\ \quad \quad = 44 \end{array}$$

$$n = \frac{22}{44} = 0.5 \text{ mol}$$

$$\frac{n_{O_2}}{0.5} = \frac{5}{1}$$

$$n = 2.5 \text{ mol}$$

$$MM(O_2) = 32$$

$$m = 2.5(32) = 80$$

32. (3 p) Given these bond energies in kJ/mol: (C - C) = 348, (C = C) = 614, (H - C) = 413, (H - H) = 436, (O = O) = 495, (C - O) = 396, (C = O) = 799, (O - H) = 463, estimate ΔH° for the following reaction: $2 \text{C}_2\text{H}_6 (\text{g}) + 7 \text{O}_2 (\text{g}) \rightarrow 4 \text{CO}_2 (\text{g}) + 6 \text{H}_2\text{O} (\text{g})$.

a) -2831 kJ ✓

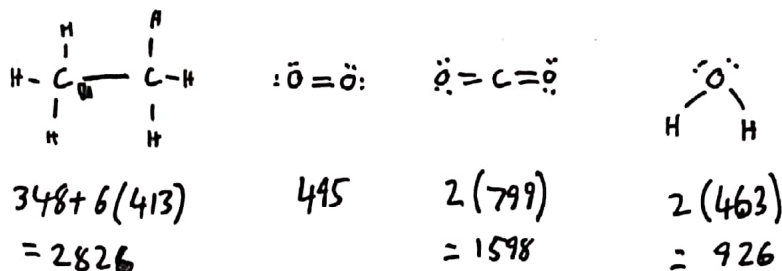
b) 2831 kJ

c) -2364 kJ

d) 2364 kJ

e) -2548 kJ

f) 2548 kJ



$$2(2826) + 7(495) - 4(1598) - 6(926) = -2831$$

33. (3p) For the reaction $\text{N}_2 + 3 \text{H}_2 \rightarrow 2 \text{NH}_3$, suppose 14 g of N_2 and 8.0 g of H_2 are present at the start of the reaction. At the end of the reaction, which one of the following will remain unreacted.

a) 3.0 g of H_2

b) 1.0 g N_2

c) 6.0 g H_2

d) 4.0 g N_2

e) 5.0 g H_2 ✓

$$\text{MM}(\text{N}_2) = 28$$

$$n = \frac{14}{28} = 0.5$$

$$\frac{n(\text{H}_2)}{0.5} = \frac{3}{1}$$

$$n = 1.5 \text{ mol}$$

$$\text{MM}(\text{H}_2) = 2$$

$$m = 3 \text{ g}$$

$$8 - 3 = 5 \text{ g}$$

34. (3p) If a solution of sucrose, $\text{C}_{12}\text{H}_{22}\text{O}_{11}$, has a molarity of 0.245 M, how many millilitres of solution are needed to obtain 50.0 g of sucrose? (molar mass of sucrose is 342.3 g/mol).

a) 158 mL

b) 456 mL

c) 596 mL ✓

d) 784 mL

e) 224 mL

$$M = \frac{n}{V} \quad n = \frac{50}{342.3} = 0.1461 \text{ mol}$$

$$V = \frac{0.1461}{0.245} = 0.596 \text{ L} \Rightarrow 596 \text{ mL}$$

35. (3p) What is the mole fraction of water in water-ethanol solution that is 54% water by mass (ethanol C_2H_5OH , molar mass 46.0 g/mol).

$$MM(H_2O) = 2(1) + 16 = 18$$

a) 0.25

b) 0.33

c) 0.46

d) 0.67

e) 0.75

$$X = \frac{(m/18)}{(m/18) + (m/46)} \quad (1)$$

$$= \frac{18(0.54)}{(18+46)(0.46)}$$

$$= 0.33$$

36. (3p) A mixture containing 2.0 mol CH_4 (g), 4.5 mol of O_2 (g) and 3.5 mol of Ne (g) exerts a total pressure of 0.80 atm. What is the partial pressure of the CH_4 (g)?

a) 0.16 atm

b) 0.40 atm

c) 0.64 atm

d) 0.80 atm

e) 0.32 atm

$$\frac{2}{10} \times 0.8 = 0.16$$

37. (3p) The density of 1.95 M solution of KBr in water is 1.16 g/mL. Find the molality of this solution. The molar mass of KBr is 119.0 g/mol. (Hint: take a convenient amount of solution such as one litre or 1 kg or one handful).

a) 1.44 mol/kg

b) 1.86 mol/kg

c) 1.95 mol/kg

d) 2.10 mol/kg

e) 2.31 mol/kg

$$M = \frac{n}{V}$$

$$\text{if } V=1, \quad \text{density} = \frac{m}{V}$$

$$n = 1.95 \text{ mol} \quad \text{molality} = \frac{n}{m}$$

$$m = 1.16 \text{ g}$$

$$\text{molality} = \frac{1.95}{1.16}$$

$$= 1.68$$