Chemistry Unit One Semester 1 Marking Guide

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1 | a □ b □ c □ d ◙ |  | 11 | a □ b ◙ c □ d □ |  |
| 2 | a □ b □ c □ d ◙ |  | 12 | a □ b □ c ◙ d □ |  |
| 3 | a □ b □ c □ d ◙ |  | 13 | a □ b □ c □ d ◙ |  |
| 4 | a □ b □ c □ d ◙ |  | 14 | a □ b □ c ◙ d □ |  |
| 5 | a □ b □ c □ d ◙ |  | 15 | a ◙ b □ c □ d □ |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 6 | a □ b □ c □ d ◙ |  | 16 | a □ b □ c ◙ d □ |
| 7 | a ◙ b □ c □ d □ |  | 17 | a ◙ b □ c □ d □ |
| 8 | a □ b □ c □ d ◙ |  | 18 | a ◙ b □ c □ d □ |
| 9 | a □ b □ c □ d ◙ |  | 19 | a □ b □ c ◙ d □ |
| 10 | a □ b ◙ c □ d □ |  | 20 | a ◙ b □ c □ d □ |

Question 21 (5 marks)

Complete the table below.

See table below.

|  |  |  |
| --- | --- | --- |
| Description |  | Marks |
| Na2CrO4 | Sodium Chromate | 1 |
| N2O4 | Dinitrogen tetroxide | 1 |
| Fe(H2PO4)3 | Iron (III) dihydrogenphosphate | 1 |
| (NH4)2SO4 | Ammonium sulfate | 1 |
| CBr4 | Tetrabromomethane/ carbontetrabromide | 1 |

No part marks.

Question 22 (16 marks)

(a) Complete the table below. (8 marks)

|  |  |  |
| --- | --- | --- |
| Structural Formula | IUPAC Name | Marks |
|  | Propene  Or prop-1-ene, 1-propene  (-1) for indicating trans etc | 2 |
|  | 2,3–dimethylpent–2–ene  1 mark – parent chain correct (with double bond in correct position and all hydrogens)  1 mark – two methyl groups | 2 |
|  | trans–hex-2-ene  (-1) no trans | 2 |
|  | 1,2–dibromo–2,3,5–trichloropentane  (-1) incorrect numbers  (-1) incorrect prefixes  (-1) error in dashes or commas. | 2 |

(b) Select one molecule from the table in part (a) that can exist as a cis isomer and draw its cis structure below. (2 marks)

|  |  |
| --- | --- |
|  | cis–hex-2-ene  (-1) missing hydrogens  No need to name |

(c) Samples of benzene and hept–1–ene appear similar in that they are colourless, clear liquids. Their chemical reactions, however are quite different. Draw the full structural formula of the organic product when bromine water reacts with each of these substances and name the product. (6 marks)

|  |  |  |
| --- | --- | --- |
| Description |  | Marks |
| 2 | 1,2–dibromoheptane  1 mark name  1 mark – hept chain  1 mark two bromo groups correct positions | 3 |
| 2 | Bromobenzene  1 mark name  1 mark single bromo group  1 mark aromatic structure with hydrogens | 3 |

NOTE NO MARK FOR FOLLOW THROUGH NAME IF STRUCTURE IS INCORRECT.

Question 23 (9 marks)

A pure sample of an element is isolated and analysed by mass spectrometry to determine its relative atomic mass. The data from this analysis is shown below.

The process of mass spectrometry involves 4 steps;

|  |  |
| --- | --- |
| 1. ionisation | 1 |
| 2. acceleration | 1 |

3. deflection

4. detection

(a) Write the names of the first 2 steps involved in mass spectrometry in the spaces above. (2 marks)

In step 3, the various particles are deflected based on their mass. (You may assume that all particles in the mass spectrometer have the same charge.)

(b) How are the particles deflected? (1 mark)

|  |  |
| --- | --- |
| - magnetic field | 1 |

(c) Explain how atoms of an element can have different masses, and elaborate on the composition of this element by using the graph on the previous page. (3 marks)

|  |  |
| --- | --- |
| - isotopes | 1 |
| - different numbers of neutrons therefore different masses | 2 |

(d) Calculate the relative atomic mass of the element. Identify this element by name or symbol. (3 marks)

|  |  |
| --- | --- |
| Ar = (4.345 x 49.946 + 83.789 x 51.941 + 9.501 x 52.941 + 2.365 x 53.939 ) / 100 | 1 |
| = 51.9966  = 52.00 | 1 |
| Element is Cr / chromium | 1 |

Question 24 (8 marks)

Lead metal can be extracted from several different compounds, the most common of which is galena, or lead(II) sulfide (PbS). The overall process for the extraction of lead from an ore containing galena can be represented by the equation below.

2 PbS(s) + 3 O2(g) + C(s) → 2 Pb(s) + 2 SO2(g) + CO2(g)

If 327 kg of galena (PbS) was available;

(a) Calculate the mass of O2(g) required to react with the PbS(s). (4 marks)

|  |  |
| --- | --- |
| m(PbS) = 327 x 103 g | 1 |
| n(PbS) = m/M  = 327 x 103 / 239.27  = 1366.6569 mol | 1 |
| n(O2) = n(PbS) x 3/2  = 2049.9854 mol | 1 |
| m(O2) = nM  = 2049.9854 x 32  = 65599.5319 g  = 65.6 kg OR 6.56 x 104 g (3 SF) | 1 |

(b) Calculate the maximum mass of Pb(s) that could be extracted from the PbS(s). (2 marks)

|  |  |
| --- | --- |
| n(Pb) = n(PbS)  = 1366.6569 mol | 1 |
| m(Pb) = nM  = 1366.6569 x 207.2  = 283171.31 g  = 283 kg OR 2.83 x 105 g (3 SF) | 1 |

(c) If the ore is 69.3% galena, calculate the starting mass of ore required. (2 marks)

|  |  |
| --- | --- |
| m(ore) = 327 x 100/69.3 | 1 |
| = 471.86 kg  = 472 kg (3 SF) | 1 |

Question 25 (11 Marks)

The structures of diamond and graphite are drawn below.

(a) State the name of the “strong bonds” shown on the diagram in the space below. (1 mark)

|  |  |
| --- | --- |
| Covalent bonds | 1 |

(b) Diamond is noted for its hardness and graphite is used as a lubricant because of its soft slippery properties.

(i) Explain why there is such a difference in this physical property of these carbon structures. (3 marks)

|  |  |
| --- | --- |
| In diamond there are only strong covalent bonds (tetrahedral structure)/ carbon bonded to four carbons | 1 |
| Whereas in graphite there is a layer structure with weak intermolecular forces of attraction | 1 |
| Therefore, less energy will be involved in overcoming the weak forces of attraction resulting in graphite being softer than diamond.(**need to mention to gain 3rd mark**) | 1 |

(ii) Explain why there is a significant difference in the electrical conductivity of diamond and graphite. (2 marks)

|  |  |
| --- | --- |
| Graphite conducts electricity, diamond does not.  Graphite has delocalised electrons between the layers that act as charge carriers. | 1 |
| All the electrons in diamond have been used in bonding. | 1 |

(c) Carbon is also found in nanomaterials. Describe how the structure of a carbon nano-particle is different in three ways from either structure in part (a). (3 marks)

|  |  |
| --- | --- |
| Size: Nano-particles are very small | 1 |
| Shape: tend to be made into a ball or tube shape | 1 |
| Structure: bonded in rings of either 5 or 6 carbons | 1 |

Accept any other relevant answers.

(d) List two possible health issues that might be related to the use of nano-particles.

(2 marks)

|  |  |
| --- | --- |
| One mark each to a maximum of two marks.  Any two of: |  |
| Properties of nano-particles differ (from the ‘bulk’ corresponding chemical) and the hazards are largely unknown | 1 |
| They are small enough to penetrate the lung cells | 1 |
| They are much smaller than body cells and so could enter body cells | 1 |

Question 26 (7 marks)

Ethanol (C2H5OH) is a fuel that is produced by two main methods. The hydration of ethene produces ethanol, whilst the fermentation of glucose produces bioethanol. Ethanol and bioethanol are identical in structure, however bioethanol is classified as a biofuel.

(a) What is a ‘biofuel’? Explain why biofuels produce a much lower level of overall carbon emissions compared to fossil fuels. (3 marks)

|  |  |
| --- | --- |
| - a fuel produced from biomass | 1 |
| - biomass has absorbed CO2 from atmosphere, this is in turn released when the fuel is combusted | 1 |
| - therefore net production of CO2 is near zero | 1 |

When liquid ethanol is combusted, it produces water vapour, carbon dioxide gas

(b) Write a balanced thermochemical equation for this combustion process. Include phase symbols. (4 marks)

|  |  |
| --- | --- |
| C2H5OH(l) + 3 O2(g) → 3 H2O(g) + 2 CO2(g) + heat | (1) reactant and product formulas shown correctly  (1) phase symbols  (1) balanced correctly  (1) heat shown as product |

Question 27 (8 marks)

Calcium carbonate is used in some toothpastes. To determine the mass of calcium carbonate in one gram of toothpaste, a 10.40 g sample of the toothpaste was reacted with hydrochloric acid solution.

When calcium carbonate reacts with hydrochloric acid solution the products are calcium chloride, water and carbon dioxide.

(a) If the molecular equation describing this reaction is

CaCO3 + 2HCℓ → CaCℓ2 + CO2 + H2O

Write a balanced ionic equation for the reaction taking place, include state symbols.

|  |  |
| --- | --- |
| CaCO3(s) + 2H+(aq) → Ca2+(aq) + CO2(g) + H2O(ℓ) | 1 |
| State symbols | 1 |

(b) If 3.570 g of carbon dioxide is produced, calculate the mass of calcium carbonate present in the 10.40 g sample. (4 marks)

|  |  |
| --- | --- |
| n(CO2) = 3.570 /44.01 = 0.08111 mol | 1 |
| n(CaCO3) = n(CO2) = 0.08111 mol | 1 |
| m(CaCO3) = nM = 0.0811 x 100.09 = 8.119 g | 1 |
| correct units | 1 |

(c) Calculate the mass of calcium carbonate in one gram the toothpaste. (1 mark)

|  |  |
| --- | --- |
| 8.12 / 10.40 = 0.781 g | 1 |

(d) By referring to the given equation in part (a) state what assumption has been made about the reaction of the acid with the toothpaste. (1 mark)

|  |  |
| --- | --- |
| That the reaction went to completion i.e. the toothpaste was the limiting reagent and there was equal or more than 2 mol of HCℓ per mol of calcium carbonate. | 1 |

Question 28 (16 marks)

A chemistry student had two unlabelled beakers, each containing a different colourless liquid. One contained hexane, CH3CH2CH2CH2CH2CH3(l), and the other hex-1-ene, CH2CHCH2CH2CH2CH3(l).

The student added a few drops of liquid bromine, Br2(l), to each beaker in order to distinguish the liquids.

(a) Why is it important that the liquid bromine be limiting (i.e. only a few drops are added) for this distinguishing test to be effective? (2 marks)

|  |  |
| --- | --- |
| - must be limiting so that colour change with alkene can be observed | 1 |
| - if present in excess then both solutions would appear red | 1 |

Whilst no immediate or visible reaction was observed to occur with the hexane, in the presence of an appropriate catalyst, a slow reaction has the potential to take place.

(b) Write a balanced equation for this reaction, including phase symbols, and name the type of reaction that is occurring. (4 marks)

|  |  |
| --- | --- |
|  |  |
| + Br2(l) → (UV catalyst)  + HBr | (1) reactants  (1) products  (1) catalyst  (1) substitution |

If 8 drops of bromine liquid are added to the beaker containing hex-1-ene and shaken;

(c) Calculate the mass of 1,2-dibromohexane produced. Assume 1 drop = 0.05 g. (4 marks)

|  |  |
| --- | --- |
| m(Br2) = 8 x 0.05  = 0.4 g | 1 |
| n(Br2) = m/M  = 0.4 / 159.8  = 0.00250313 mol | 1 |
| n(C6H12Br2) = n(Br2)  = 0.00250313 mol | 1 |
| m(C6H12Br2) = nM  = 0.00250313 x 243.956  = 0.610653 g  = 0.6 g (1 SF) | 1 |

If hex-3-ene had been used in place of hex-1-ene in the reaction above;

(d) Draw and name the product of the reaction. (2 marks)

|  |  |
| --- | --- |
| IUPAC name: 3,4-dibromohexane | 1 |
|  | 1 |

The organic substance ‘citronellol’ is found in citronella and essential oils isolated from lemongrass. It is used in soaps, candles, incense, cosmetics and insect repellents. A molecule of citronellol is shown below.

A pure sample of liquid citronellol was mixed with a few drops of iodine water, I2(aq).

(e) Write a balanced equation for the reaction that would take place and name the type of reaction occurring. (2 marks)

Equation: Type of reaction: addition

(f) Calculate the percent by mass of carbon in citronellol. (2 marks)

|  |  |
| --- | --- |
| MF(citronellol) = C10H20O  M(citronellol) = 10 x 12.01 + 20 x 1.008 + 16 = 156.26 | 1 |
| %C = (10 x 12.01) / 156.26 x 100  = 76.859%  = 76.86% (4 SF) | 1 |

Question 29 (14 marks)

Design a process where, if you were given a mixture of iron filings, salt and charcoal, you could separate each component.

(a) Prepare a list of essential equipment you will need to request to complete this exercise.

|  |  |
| --- | --- |
| Safety items  Any two of:  · Glasses  · bench mat | 1-2 |
| Adequate equipment list | 1-3 |

(b) Describe how you would separate the different substances from the mixture. Identify the separation techniques you would choose and show two details of how each one specifically separates an item from the mixture. (9 marks)

|  |  |
| --- | --- |
| Separation technique - Magnet | 1 |
| Iron filings can be separated by the use of a magnet | 1 |
| Water is added to the remaining mixture | 1 |
| Separation technique - Filtration | 1 |
| Any two of:  · Salt dissolves and charcoal does not  · The charcoal is separated by filtration  · Charcoal is the residue  · Saltwater is the filtrate  · Particle size | 1-2 |
| Separation technique - Crystallisation | 1 |
| Any two of:  · Salt water now is heated  · Allow to cool  · Salt crystallises out | 1-2 |

Question 30 (16 marks)

Sodium (Na), magnesium (Mg), sulfur (S8) and chlorine (Cl2) are all elements located in period 3 of the Periodic Table.

(a) State and explain the trend in electronegativity across period 3. (3 marks)

|  |  |
| --- | --- |
| - electronegativity increases across period 3 | 1 |
| - an increase in the number of protons in the nucleus and a decrease in atomic radius | 1 |
| - means that the period 3 elements attract electrons more strongly (from left to right) i.e. have a higher electronegativity | 1 |

Sodium and magnesium are both good conductors of electricity while sulfur and chlorine are not.

(b) Explain this difference in terms of the structure and bonding of the species present in these elements. (3 marks)

|  |  |
| --- | --- |
| - Na and Mg are both metallic | 1 |
| - The delocalised electrons act as mobile charge carriers | 1 |
| - S8 and Cl2 are covalent molecules that have no mobile charge carriers | 1 |

Consider two of the ionic compounds that could form from these elements; sodium chloride (NaCl) and magnesium sulfide (MgS).

(c) Using the concepts of ionisation energy and electronegativity, explain how the chemical bonds within NaCl or MgS form. (4 marks)

|  |  |
| --- | --- |
| - Na/Mg have low ionisation energy, i.e. small amount of energy required to remove electron | 1 |
| - Cl/S have high electronegativity, i.e. exert strong attraction on an electron | 1 |
| - The metallic Na/Mg will therefore easily donate 1 or 2 electrons respectively to the non-metals | 1 |
| - The oppositely charged metal cations and the non-metal anions will now attract and form ionic bonds | 1 |

Question 31 (16 marks)

|  |  |  |
| --- | --- | --- |
| **Physical or Chemical Change** | **Process is exothermic or endothermic** | **Enthalpy of products (H) is higher/lower** |
| Propane gas is burnt | Exothermic | Lower |
| Ice is placed in water and melts | Endothermic | Higher |
| The two atoms making up an oxygen molecule are separated | Endothermic | Higher |
| Solid carbon dioxide (dry ice) sublimes to its gaseous form | Endothermic | Higher |
| A sodium gas ion gains an electron to become sodium gas | Exothermic | Lower |

Fuels such as methane combust by reaction with oxygen to produce carbon dioxide and water. This process is accompanied by the release of heat energy to the surroundings.

(a) Write the equation for the combustion of octane. Include the energy term in your equation. (2 marks)

Description Marks

|  |  |
| --- | --- |
| 2 C8H18(g) + 25 O2(g) → 16 CO2(g) + 18 H2O(g) + heat | 1 |
| Heat/Energy shown  Note: No penalty if state symbols not shown. | 1 |

The heats of reaction for the combustion of some alkanes are shown in the table below.

|  |  |
| --- | --- |
| Fuel | ∆H (kJ mol–1) |
| methane | -890 |
| butane | -2881 |
| Pentane | -3536 |
| octane | -5510 |

(b) Plot ∆H (kJ mol–1) of the combustion reaction versus the number of carbon atoms in each compound on the grid below. (2 marks)

|  |  |
| --- | --- |
| Points plotted correctly | 1 |
| Straight line of best fit | 1 |

(c) State the relationship between the number of carbon atoms in the fuel compound and ∆H. (1 mark)

|  |  |
| --- | --- |
| ∆H decreases (i.e., becomes more negative) as the number of carbon atoms increases. | 1 |

Predict, and write below, an approximate value for the heat of reaction for the combustion of hexane. (1 mark)

|  |  |
| --- | --- |
| ~ -4200 +/- 100 kJ mol–1 | 1 |

Hydrogen gas may also be used as a fuel, and reacts with oxygen when ignited to form water according to the reaction below.

2 H2(g) + O2(g) → 2 H2O(ℓ)

1200 kg of hydrogen gas is ignited in air to form H2O.

(e) What volume of oxygen gas will react with this mass of hydrogen at S.T.P.? Your answer must be expressed with the appropriate number of significant figures and must include units. (4 marks)

|  |  |
| --- | --- |
| 1200 × 1000g = 1200 000 g | 1 |
| n(H2) = m/M  = 1200000/(2.016)  = 595238.1 mol (5.952380952 × 105 mol) | 1 |
| 2 mol H2: 1 mol O2,  ∴ n(O2) = 2.976190476 ×105 mol | 1 |
| V(O2) = n(22.71)  = 6.8 x 106 L (2 S.F) | 1 |

(f) Given that air is approximately 20% oxygen by volume, what volume of air would be required to react with 1200 kg of hydrogen gas? (1 mark)

|  |  |
| --- | --- |
|  |  |
| (6.6 x 106) x (1/0.2)  3.4 x 107 L | 1 |