HIGHER LEVEL (HL) DP CHEM SUMMER ASSIGNMENT

Incoming 12th graders

Summer 2023

1. This packet is due on the first day of class during the Fall 2023 semester.

2. Complete all questions on separate sheets of paper or an electronic document. **Show all work**.

3. Remember: Completing this packet will ensure that you are prepared for 12th Grade DP Chemistry and ready to re-take your 11th Grade DP Chemistry Final during the first week of class. This is a large packet so do not wait until the last minute to complete it.

1 Tin(II) chloride may be prepared by passing hydrogen chloride gas over heated tin:

$Sn(s) + 2HCl(g) \rightarrow SnCl_2(s) + H_2(g)$

When 5.00 g of tin is reacted with excess hydrogen chloride, 7.46 g of $SnCl_2$ is obtained. What is the percentage yield of $SnCl_2$? [3]

2 When silver nitrate is reacted with solutions containing chloride ions, insoluble silver chloride is precipitated:

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$

a What mass of silver chloride is precipitated when 20.0 cm^3 of 0.100 mol dm^{-3} sodium chloride solution is reacted with excess silver nitrate solution? [3]

b What mass of silver chloride is precipitated when 25.0 cm^3 of 0.0600 mol dm^{-3} silver nitrate solution is added to 20.0 cm^3 of 0.100 mol dm^{-3} sodium chloride solution? [5]

c What mass of silver chloride is precipitated when 30.0 cm^3 of 0.0800 mol dm^{-3} silver nitrate solution is added to 20.0 cm^3 of 0.0800 mol dm^{-3} $CaCl_2(aq)$? [6]

d 0.0100 mol of a metal chloride (MCl_x) is dissolved in water then reacted with excess silver nitrate solution. The mass of silver chloride precipitated was 4.30 g.
Determine the value of x. [2]

e 1.45 g of a mixture of sodium chloride and potassium chloride is dissolved in water and made up to a total volume of 250.0 cm^3. Excess 0.100 mol dm^{-3} silver nitrate solution is added to 25.00 cm^3 of this solution. 0.325 g of AgCl is precipitated. Determine the percentage NaCl and KCl in the original mixture. [6]

3 In each of the following cases work out the relative atomic mass of the element to **two** decimal places:

a Rhenium has two naturally occurring isotopes with natural abundances:

^{185}Re 37.40% ^{187}Re 62.60% [2]

b Neodymium has seven naturally occurring isotopes with abundances:

^{142}Nd 27.13% ^{146}Nd 17.19%
^{143}Nd 12.18% ^{148}Nd 5.76%
^{144}Nd 23.80% ^{150}Nd 5.64%
^{145}Nd 8.30% [2]

4 Europium has two naturally occurring isotopes, Eu-151 and Eu-153, and a relative atomic mass of 151.96. Calculate the percentage abundance of each isotope of europium. [2]

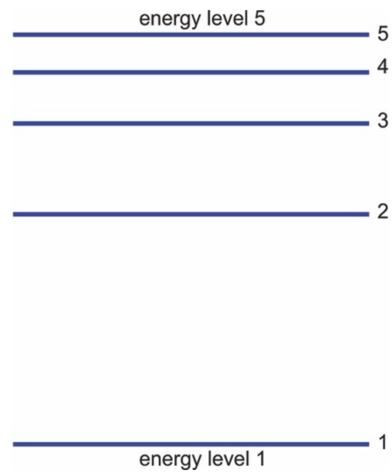
5 The emission spectrum of hydrogen in the visible region, when observed through a spectroscope, consists of a series of coloured lines on a black background. Explain how the different lines in the spectrum arise. [3]

6 The diagram on the right represents the energy levels in a hydrogen atom. Draw arrows on the diagram to represent the following transitions: [3]

a a line in the infrared spectrum of a hydrogen atom

b the lowest energy line in the visible spectrum of hydrogen

c a line in the ultraviolet spectrum of a hydrogen atom.



7 Write an equation for the ionisation energy of hydrogen and explain what is meant by the term ‘convergence limit’.

8 Write out the full electronic configurations of the following atoms: [8]

a $_{16}S$

b $_{35}Br$

c $_{26}Fe$

d Sn

e Sr

f Xe

g Cu

h Cr

9 Write out the full electronic configuration of the following ions: [8]

a Ca^{2+}

b Br^{-}

c P^{3-}

d Sn^{2+}

e I^{-}

f Sc^{3+}

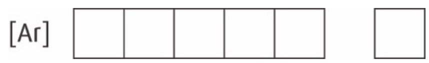
g Ti^{2+}

h Cu^{2+}

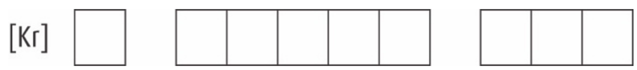
10 Complete the following diagrams, showing electrons in boxes: [3]

a Al

b Co



c Te



11 Write equations to represent the following processes: [3]

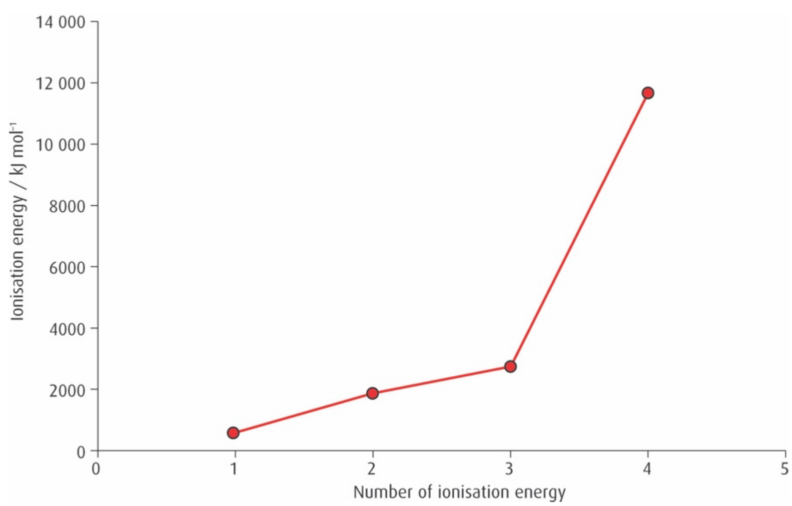
a the first ionisation energy of sodium

b the second ionisation energy of chlorine

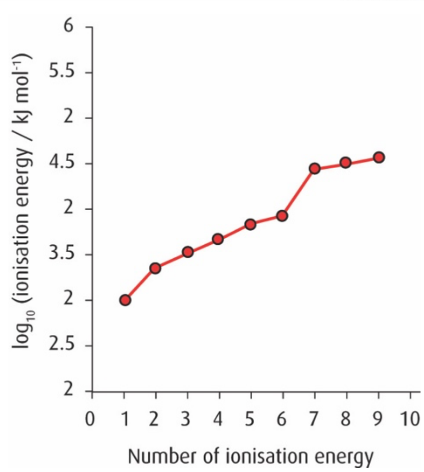
c the fifth ionisation energy of lead.

12 From the graphs of successive ionisation energy given below, **explain** in which group of the periodic table each element is. [6]

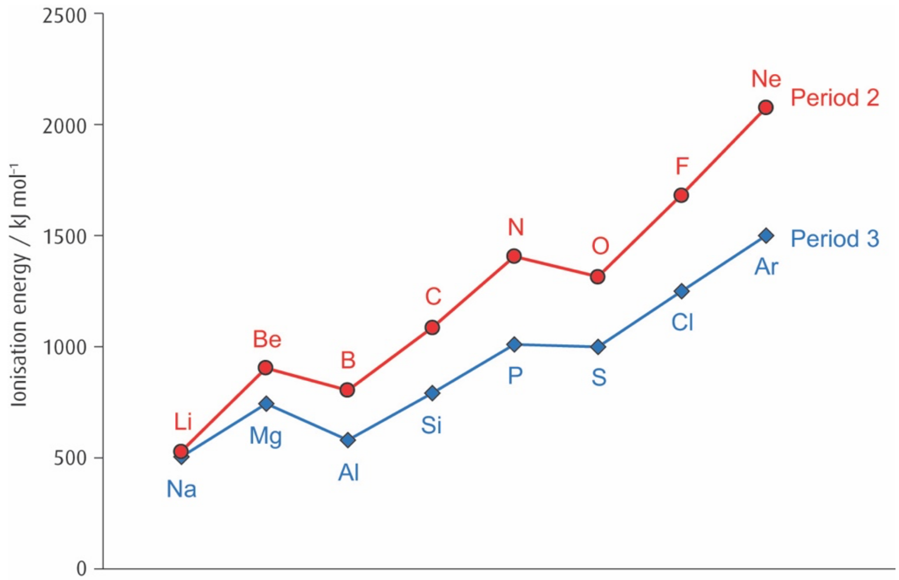
a



b



13 The graphs below show the first ionisation energies of the elements in Period 2 and Period 3. **Explain** the similarities and differences between the graphs. [10]



14 **a** Explain why ionic compounds have high melting points. [1]

b Explain as far as possible the following data: [3]

Compound	**Melting point / °C**
sodium chloride	801
magnesium oxide	2852
calcium oxide	2614
caesium chloride	645

15 Draw Lewis structures for the following molecules. Work out the shapes and predict bond angles: [30]

a H_2O

b NH_3

c Cl_2O

d CO_2

e PF_3

f BF_3

g C_2H_4

h N_2H_4

i H_2O_2

j O_3

16 Draw Lewis structures for the following ions. Predict the shapes and suggest bond angles: [12]

a CO_3^{2-}

b NH_4^+

c NO_2^+

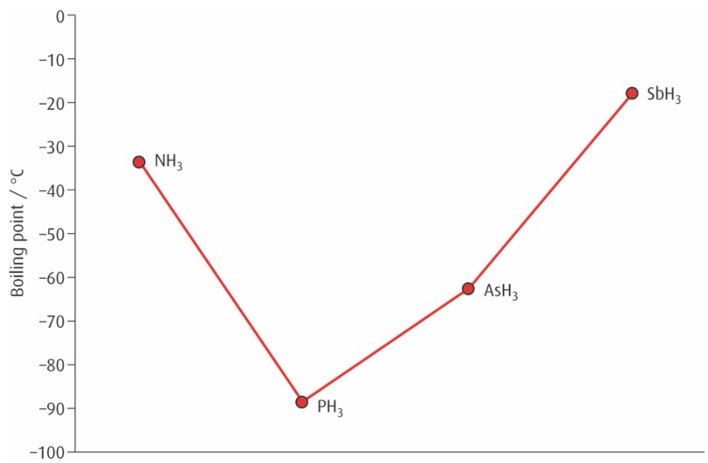
d NO_2^-

17 Explain what is meant by **electronegativity**. [1]

18 Select the polar molecules from the following list. For the polar molecules draw diagrams showing the dipoles. [8]

H_2O NH_3 Cl_2O CF_4 CO_2
PF_3 BF_3 H_2 N_2 O_3

19 The boiling points of the hydrides of group 5 are plotted in the graph below. **Explain** the trends shown. [5]



20 **a** Explain why diamond has a very high melting point. [4]

b Explain how the structure of graphite differs from that of diamond. [4]

21 **a** Explain, using a diagram, the bonding in a metal such as sodium. [2]

b Explain why magnesium has a higher melting point than sodium. [4]

22 Draw Lewis structures for the following molecules/ions. Predict the shapes and suggest bond angles:

a BrF_3

b ClO_4^-

c ICl_4^-

d BrF_2^+

e F_3ClO_2

f XeF_2

g XeO_3

h XeO_2F_2

i XeO_6^{4-}

23 Suggest the hybridisation at the atom shown in bold in each of the following: [8]

a $H_2\mathbf{S}$

b $\mathbf{P}H_3$

c $\mathbf{C}O_2$

d $\mathbf{N}O_2^+$

e $F_2\mathbf{C}CF_2$

f $H_2\mathbf{N}NH_2$

g $H_3\mathbf{O}^+$

h $HO\mathbf{O}H$

24 **a** Give the formula of the carbonate ion. [1]

b Draw a Lewis structure for the carbonate ion. [1]

c Some C–O bond lengths are given in the following table:

	Bond length / nm
C–O	0.143
C=O	0.122
C≡O	0.113

Explain why all the C–O bond lengths are equal in the carbonate ion and use the information in Table 10 of the Data Booklet to suggest a value for the C–O bond length in the carbonate ion. [3]

25 Explain the following:

a Potassium has a lower first ionisation energy than lithium. [4]

b Fluorine is the most electronegative element in the periodic table. [4]

c A chlorine atom is smaller than a sodium atom. [4]

d A chloride ion is larger than a sodium ion. [2]

26 Complete and balance the following equations: [2]

a $Na + H_2O \rightarrow$ _______________

b $Cl_2(aq) + KBr(aq) \rightarrow$ _______________

27 Write equations for the reactions of the following oxides with water: [4]

a sodium oxide

b magnesium oxide

c phosphorus(V) oxide

d sulfur(VI) oxide

28 **a** **Explain** the term **ligand**. [1]

b Work out the oxidation number of the transition metal in the following complex ions/compounds: [6]

i $[Ni(CN)_4]^{2-}$

ii $[NiF_6]^{2-}$

iii $[CrCl_4]^{-}$

iv $[Fe(CO)_5]$

v $KMnO_4$

vi $Na_2[FeCl_4]$

29 The $[Ni(H_2O)_6]^{2+}$ complex ion is green. Explain in terms of electronic structure why this complex ion is coloured. [5]

30 50.0 cm^3 of 1.50 mol dm^{-3} sodium hydroxide is mixed with 100.0 cm^3 of 1.00 mol dm^{-3} hydrochloric acid. Both solutions were initially at 19.3 °C and when they were mixed the temperature rose to a maximum of 28.3 °C.

a Write an equation for the reaction that occurs. [1]

b Calculate the number of moles of sodium hydroxide and of hydrochloric acid. [2]

c Calculate the enthalpy change of neutralisation. [3]

31 Given these enthalpy changes:

$CH_3CH_2CH_2OH(l) + {}^9/_2O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^\ominus = -2010$ kJ mol^{-1}

$CH_3CH_2CH_2OH(g) + {}^9/_2O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$ $\Delta H^\ominus = -2055$ kJ mol^{-1}

calculate the enthalpy change for the following process: [2]

$CH_3CH_2CH_2OH(g) \rightarrow CH_3CH_2CH_2OH(l)$

32 Use the bond energies given in the table to calculate enthalpy changes for reactions below.

Bond	**Bond enthalpy / kJ mol^{-1}**
C–C	348
C=C	612
C≡C	837
N–N	163
N=N	409
N≡N	944

Bond	**Bond enthalpy / kJ mol^{-1}**
C–H	412
N–H	388
O–H	463
O–O	146
O=O	496
H–H	436

Bond	**Bond enthalpy / kJ mol^{-1}**
C–O	360
C=O	743
C≡O	1070
Cl–H	431

a $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(g)$ [5]

b $CO(g) + 3H_2(g) \rightarrow CH_4(g) + H_2O(g)$ [5]

c $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$ [5]

33 Use the data given below and the bond energies in question 8 to calculate the Cl–Cl bond energy. [5]

$$4HCl(g) + O_2(g) \rightarrow 2H_2O(g) + 2Cl_2(g) \qquad \Delta H^\ominus = -112\ \text{kJ mol}^{-1}$$

34 Write equations to represent the enthalpy change of formation of the following: [3]

a $C_6H_6(l)$

b $CH_3CHO(l)$

c $Li_3N(s)$

35 Calculate the enthalpy changes for the following reactions given the data in the table.

	$\Delta H_f^\ominus$ / kJ mol^{-1}
$SO_2(g)$	–297
$PCl_5(s)$	–444
$SOCl_2(l)$	–246
$Cl_2O(g)$	80
$POCl_3(l)$	–597
$NH_3(g)$	–46
$NH_4Cl(s)$	–314
$H_2O(g)$	–242

a $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$ [2]

b $3Cl_2O(g) + 10NH_3(g) \rightarrow 2N_2(g) + 6NH_4Cl(s) + 3H_2O(g)$ [2]

36 Construct a Born–Haber cycle showing the formation of calcium fluoride and use it and the data in the table below to predict the lattice enthalpy of calcium fluoride. [6]

$\Delta H_{at}(Ca(s))$	193 kJ mol^{-1}
$\Delta H_{at}(F_2(g))$	79 kJ mol^{-1}
first ionisation energy (Ca)	590 kJ mol^{-1}
second ionisation energy (Ca)	1150 kJ mol^{-1}
first electron affinity (F)	–348 kJ mol^{-1}
$\Delta H_f(CaF_2(s))$	–1214 kJ mol^{-1}

37 State and explain the trends in lattice enthalpy shown in the table below. [6]

Substance	**Lattice enthalpy / kJ mol^{-1}**
LiF	1022
NaF	902
KF	801
MgO	3889
CaO	3513
SrO	3310

38 Predict, with a reason, whether each of the following reactions involves an increase or decrease in entropy.

a $3Cl_2O(g) + 10NH_3(g) \rightarrow 2N_2(g) + 6NH_4Cl(s) + 3H_2O(g)$ [2]

b $NCl_3(l) + 2NO(g) \rightarrow ClNO(g) + N_2O(g) + Cl_2(g)$ [2]

39 Use the data in the table to calculate the entropy change for the following reactions:

	$S^\ominus$ / J K^{-1} mol^{-1}
$SO_2(g)$	248
$PCl_5(s)$	167
$SOCl_2(l)$	308
$N_2H_4(l)$	121
$POCl_3(l)$	223
$O_2(g)$	205
$N_2(g)$	192
$H_2O(g)$	188

a $SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$ [2]

b $N_2H_4(l) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$ [2]

c Use your answer from question 35 and part (a) to predict whether the reaction:

$SO_2(g) + PCl_5(s) \rightarrow SOCl_2(l) + POCl_3(l)$

is spontaneous at 298 K. [4]

40 **a** Use the values given in the table to calculate $\Delta G^\ominus$ for the reaction:

$Cl_2(g) + 2NO(g) \rightarrow 2ClNO(g)$ [2]

	$\Delta G_f^\ominus$ / kJ mol^{-1}
$ClNO(g)$	66
$NO(g)$	87

b Predict whether this reaction will be more spontaneous at 300 K or 500 K. [3]