Section A
Answer all questions in this section in the spaces provided
The total mark for this section is 50

1 (2020/O/GCSE/P2/01) all

(a) Use the list of substance to answer the questions.

Argon
Copper
Calcium hydroxide
Ethanol
Graphite
Iron
Hydrogen

(i) Which substance do farmers use to treat acidic soil?

______________________________ [1]

(ii) Which two substances are involved in the manufacture of ammonia?

______________________________ [1]

(iii) Which substance, other than iron, is used in the manufacture of steel?

______________________________ [1]

(iv) Which substance is commonly used as a solvent?

______________________________ [1]

(v) Which substance is used as a lubricant?

______________________________ [1]

(vi) Give two substances from the list that can be oxidised by oxygen to form non-metal oxides

______________________________ [1]

(b) Fractional distillation of crude oil produces a range of substances that have many uses. Which statements about the products of fractional distillation of crude oil are true and which are false?
Put a tick (✓) in one box in each row.

	True	False
Naphtha is used as a source of chemicals for the petrochemical industry		
Paraffin is used as a fuel for aircraft		
Bitumen is used to make waxes.		
Gasoline is used to make lubricating oils for cars.		

[2]
[Total: 8]

2 (2020/O/GCSE/P2/02) (rates)

(a) Nitrogen gas and oxygen gas do not react together under normal conditions in the atmosphere.
Under the conditions in car engine, nitrogen gas reacts with oxygen gas to produce nitrogen monoxide, NO
Use ideas about energy and collisions to explain why.

____

____

____ [3]

(b) In the atmosphere, nitrogen monoxide can undergo two further reactions to form nitric acid. Nitric acid is one cause of acid rain.

In the first reaction, nitrogen monoxide reacts with oxygen to form nitrogen dioxide.

(i) Write an equation for each of the reactions that form nitric acid from nitrogen monoxide.
Equation 1:

____

Equation 2:

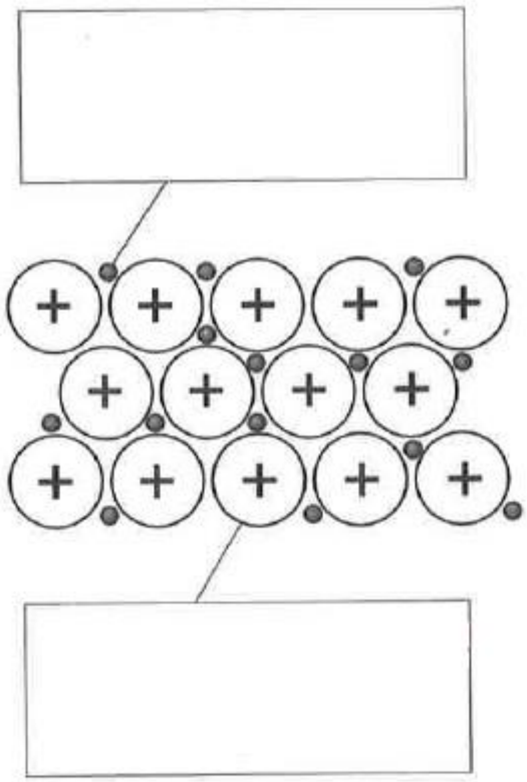
____
[2]

(ii) Name one other pollutant gas which causes acid rain.

______________________________ [1]

[Total: 6]

3 (2020/O/GCSE/P2/03) (chem bonding and metals) Figs. 3.1 and 3.2 show diagrams of the structure of the metal and an ionic compound.



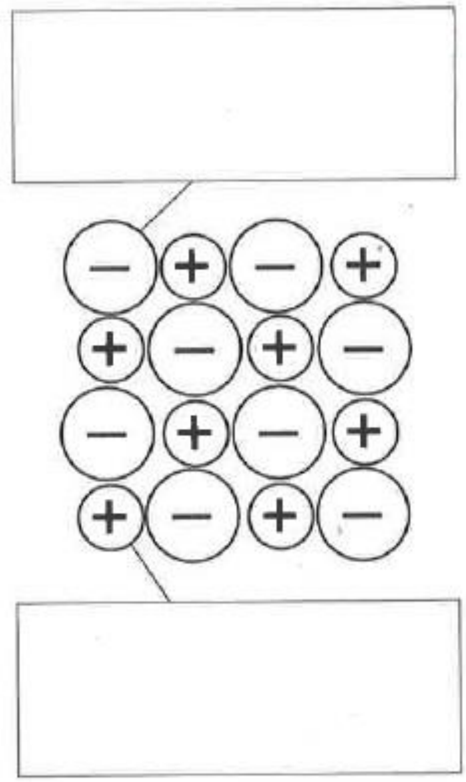


Fig 3.1. structure of a metal Fig. 3.2 structure of an ionic compound

(a) Complete the labels on the diagrams.

[2]

(b) Metals and ionic compounds can both conduct electricity.
Describe how metals and ionic compounds conduct electricity.

____

______________________________ [2]

(c) Mild steel is an alloy of iron
Student finds this diagram of mild steel (Fig. 3.3)

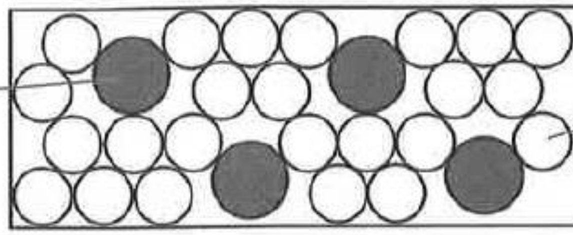


Fig. 3.3

(i) Mild steel has different properties from pure iron. It is stronger and more brittle
Explain how this diagram shows why mild steel has different properties from pure iron.

____

____ [2]

(ii) Table 3.1 shows some information about mild steel.

Table 3.1

Element in mild steel	Percentage composition by mass	Atomic radius /nm
Carbon	Up to 0.25	0.077
Iron	Approximately 99	0.126
Manganese	Approximately 0.4	0.132

(1 000 000 000 nm) = 1 m

Give reasons why the diagram is not an accurate representation of the arrangement of atoms in mild steel

____

____ [2]

[Total: 8]

4 (2020/O/GCSE/P2/04) (electrolysis and organic chemistry polymers) Sealed metal cans are used to store food for long periods.
The cans stop water and oxygen from coming into contact with the food.

(a) In the past, food cans were made from iron.
A thin layer of tin metal was electroplated onto the can.
Describe the set-up that could be used to electroplate a layer of tin onto an iron can.
Include reference to electrodes and an electrolyte in your answer.

____

____

______________________________ [3]

(b) When these cans are opened, dilute acids in the food cause the tin to corrode very quickly to form tin(II) ions, Si^{2+}

Tin (II) ions are toxic, so the food should not be stored in the can after it is opened.

Write an ionic equation, with state symbols, to show the reaction between a dilute acid and tin.

______________________________ [2]

(c) Modern food cans are made from iron lined with layer of poly(ethene)

(i) Give reason why poly(ethene) is a better choice than tin for lining iron food cans.

______________________________ [1]

(ii) Poly(ethene) is a macromolecule made by addition polymerisation.
Explain the terms macromolecule and addition polymerisation.

Macromolecule

____

____

Addition polymerisation

____

____

______________________________ [3]

[Total: 9]

5 (2020/O/GCSE/P2/05) (chem bonding) Table 5.1 shows the formulae of some oxides of elements.
The shading indicates the type of structure of each oxide.

Table 5.1

Group					
I	II	III	IV	V	VI
Li_2O Na_2O	BeO MgO	B_2O_3 Al_2O_3	CO_2 SiO_2	NO_2 P_2P_5	O_2 SO_2

Giant lattices (arrow to Group II) Simple molecules (arrow to Group V)

(a) Carbon and silicon are elements in Group IV of the Periodic Table
Their oxides have very different melting points.
Explain how and why the melting points of carbon dioxide and silicon dioxide are different.

____

____

____ [3]

(b) From the table give formula of one acidic oxide and one basic oxide.

Acidic oxide ____

Basic oxide ____ [1]

(c)

(i) Draw 'dot-and-cross' diagrams to show the bonding in MgO and O_2
Show outer electrons only.

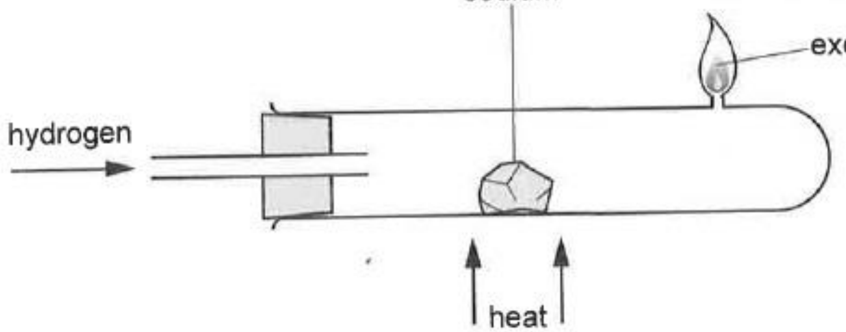
[4]

(ii) Discus the differences between the way that bonds are formed in MgO and O_2.

[2]

[Total: 10]

6 (2020/O/GCSE/P2/06) (metals - reduction of oxides) When sodium is heated in a stream of hydrogen, sodium hydride, NaH, is formed.



Other Group I metals react with hydrogen in a similar way.

Some students calculated the theoretical mass of metal hydride that can be produced per gram of hydrogen that reacts.

Table 6.1 shows their results.

Table 6.1

Group I metal	Theoretical mass of metal hydride produced per gram of hydrogen / g
Lithium	8.0
Sodium	24.0
Potassium	40.0

(a) Write a general equation to show the reaction of a Group I metal with hydrogen Use M as the symbol for the Group I metal.

[1]

(b) The students make these statements about the results.

Jean : 'The amount of metal hydride made from one gram of hydrogen increases down the group'

Beth: 'The amount of metal hydride made from one gram of hydrogen is the same for every metal'

Ryan: 'the mass of metal hydride increases by exactly the same amount down the group. I predict that if rubidium is used, 56.0 g of rubidium hydride will be made per gram of hydrogen.'

(i) Does the information in the table support the statements made by Jean and Beth?
Explain your reasoning

____

____ [2]

(ii) Do you agree with Ryan's statements?
Explain your answer in words or by means of a calculation.

____

____ [2]

(c) When sodium id heated in hydrogen, the metal grows as an exothermic reaction takes places.
How would the observations differ when potassium is heated in hydrogen?
Explain your answer.

____

____ [2]

(d) When oxygen reacts with hydrogen to form water, oxygen is reduced.
When sodium reacts with hydrogen to form sodium hydride, NaH, sodium is oxidised.
Use oxidation states to show that oxygen is reduced but sodium is oxidised when each reacts with hydrogen.

____

____ [2]

[Total: 9]

Section B

Answer all three questions in this section.

The last questions is in the form of an either/or and only one of the alternatives should be attempted.

7 (2020/O/GCSE/P2/07) (salt prep, energy changes) Choosing and using de-icers

In some countries, winter temperatures fall below 0°C and ice forms on roads. This causes accidents because vehicles slide on the slippery surface. De-icers are mixtures of chemical compounds that are spread on the roads to melt the ice.

The most commonly used de-icer is sodium chloride. It is used because it is very inexpensive. Calcium chloride is also used in smaller areas such as paths and car parks.

Effect of the mass of de-icer used

A scientist wanted to find out if mixtures containing a higher mass of de-icer have lower freezing points. She made solutions by adding different masses of sodium chloride to 100 cm^3 samples of water at room temperature. She then measured the freezing point of each solution. She repeated the experiment with different masses of calcium chloride. Tables 7.1 and 7.2 show her results

Table 7.1

Mass of sodium chloride added/g	Freezing point /°C
10	-8
20	-20
30	-15
40	Does not fully dissolve

Table 7.2

Mass calcium chloride added/g	Freezing point /°C
10	-9
20	-20
30	-45
40	+12

More about the chemistry of de-icers

The surface of ice has very thin layer of water. The de-icer dissolves in this water and lowers its freezing point. This stops the water from freezing.

Some de-icers dissolve exothermically. This helps to melt the solid ice under the layer of water and allows the de-icer to work deeper in the ice.

The enthalpy change that happens during dissolving is the enthalpy change of solution, ΔH_{sol}.

During very cold conditions, there may be very little liquid water for the de-icer to dissolve in. Some de-icers attract water vapour from the air and can use this to form a solution on the surface of the ice. De-icers that act in this way are known as hygroscopic.

Table 7.3 shows some information about some commonly used de-icers.

Table 7.3

Compound	Lowest effective temperature*/°C	ΔH_{sol} in kJ/mol	Hygroscopic	Other information
$NaCl$	-7	+3.9	No	Speeds up corrosion of metals, harmful to plants
$CaCl_2$	-32	-82.9	Yes	Speeds up corrosion of metals, harmful to plants
$MgCl_2$	-18	-155	Yes	Speeds up corrosion of metals, harmful to plants
KCl	-4	+17.2	No	Speeds up corrosion of metals, harmful to plants
CH_4N_2O (urea)	-4	-15.0	No	Low toxicity

*temperature at which water freezes in the presence of de-icer

(a) Use the data to estimate the number of moles of sodium chloride that dissolve in 1 dm^3 of water

[1]

(b) What are the similarities and differences in the results of the scientist's experiment for sodium chloride and calcium chloride?

____

____

____ [3]

(c) Some of the de-icers are effective at much lower temperatures than others.
Identify two factors that determine which de-icers are more effective at very low temperatures.
Explain your answer.

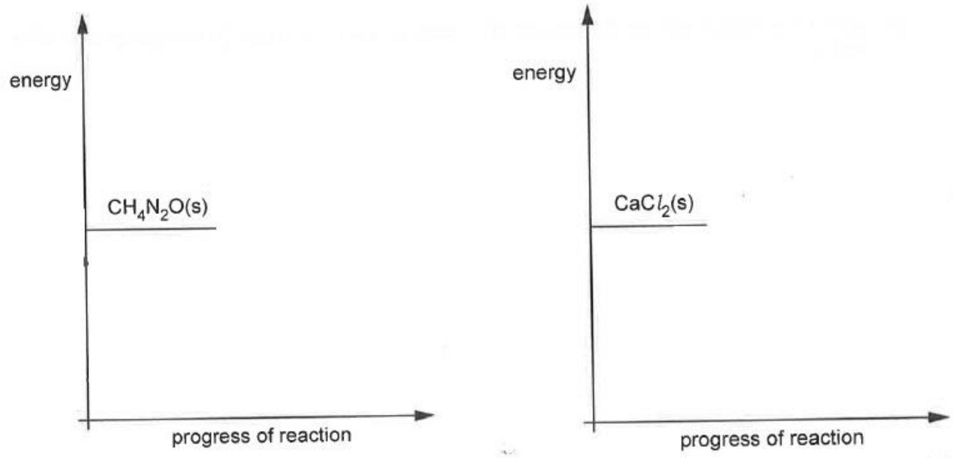
____

____

____ [3]

(d)

(i) Complete the energy level diagrams to show the products and energy changes of solution when area, CH_4N_2O, and calcium chloride, $CaCl_2$, dissolve in water



[3]

(ii) Suggest one benefit of using urea rather than calcium chloride as a de-icer.

____

____ [1]

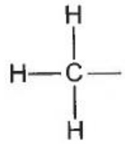
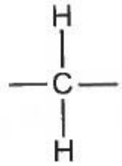
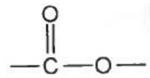
(e) Some of the de-icers are harmful to plants
This is because they contain a very high concentration of a particular ion.
Which ion in these de-icers is most likely to be harmful to plants at high concentration?
Explain your reasoning.

____

____ [1]

[Total: 12]

8 (2020/O/GCSE/P2/08) (organic chem QA) Compounds X, Y and Z are isomers.
The table shows some information about each isomer.

Isomer	Number of  Present	Number of  present	Number of  present	Empirical formula	Mr	pH of 0.1 mol/dm^3 solution
X	1	2	1	C_2H_4O	88	3
Y	2	0	1	C_2H_4O	88	3
Z	2	1	1	C_2H_4O	88	Insoluble in water

(a) Which data in the table best supports the statement that X, Y and Z are isomers?

____

____ [1]

(b) Use the information in the table deduce and draw the structural formula for each isomer.
Identify the functional group present in each isomer.

Isomer X

Functional group ____

Isomer Y

Functional group ______________________________

Isomer Z

Functional group ______________________________ [5]

(c) Magnesium was added to a solution of isomer X and to a solution of isomer Y. State and explain what you would expect to observe during these reactions. Include reference to rate of reaction in your answer.

____

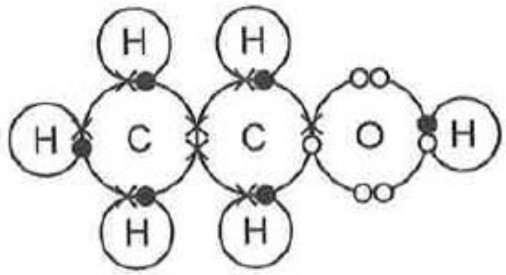
______________________________ [2]

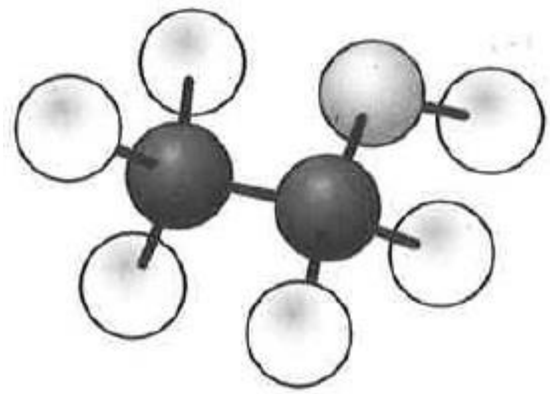
[Total: 8]

Either

9 (2020/O/GCSE/P2/09) (chem bonding) Several types of formulae, diagrams and models can be used to represent a molecule of ethanol.

Two representations are shown.





'dot-and-cross' Ball and stick model

Tables 9.1 and 9.2 show some additional information about the length of the bonds in a molecule of ethanol and the atomic radius of each atom in ethanol.

Table 9.1

Bond	Length of bond /nm
C—H	0.109
C—C	0.154
C—O	0.143
O—H	0.096

Table 9.2

Atom	Atomic radius /nm
C	0.077
H	0.037
O	0.073

(1000 000 000 nm = 1m)

(a) Explain why neither the 'dot-and-cross' diagram nor the ball and stick model is an accurate representation of an ethanol molecule.

____

____

____________________ [3]

(b) The molecular and empirical formulae of ethanol are identical.

(i) Deduce the molecular formula of ethanol

____________________ [1]

(ii) Explain why the molecular and empirical formulae of ethanol are identical.

____

____ [1]

(c) Ethanol can be made on an industrial scale by reacting ethene with steam in a reactor.

$$C_2H_4(g) + H_2O\ (g) \rightleftharpoons C_2H_5OH\ (g)$$

(i) A volume of 1000 dm^3 of ethene is measured at room temperature and pressure.
The ethene is mixed with steam and then enters the reactor.
The yield of ethanol from the reaction is 5%
Calculate the mass of ethanol formed at room temperature and pressure.
(one mole of gas occupies 24 dm^3 at room temperature and pressure)

[4]

(ii) Suggest how the process is managed to keep the waste of ethene to a minimum.

____

____ [1]

[Total: 10]

10 (2020/O/GCSE/P2/10) Moles, Ammonia, separating techniques Ammonium sulfate is a fertiliser

The table shows some information about two industrial processes that are used to make ammonium sulfate. In each process, ammonium sulfate is the useful product.

Process	Equation	Atom economy
1	$2NH_3(g) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$	100%
2	$(NH_4)_2CO_3(aq) + Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow (NH_4)_2SO_4(aq)\ CaCO_3(s)$	>50%

The atom economy of a process is a measure of the percentage by mass of the products that are useful.

$$\text{Atom economy} = \frac{Mr\ of\ useful\ product}{total\ Mr\ of\ products} \times 100\%$$

(a)

(i) The table says that the atom economy for process 2 is >50%
Calculate the actual atom economy of process 2.

[2]

(ii) Suggest reasons why the atom economies of the two processes are different.

____

____ [2]

(b) In process 1, 1000 dm^3 ammonia, measured at room temperature and pressure, is added to the reactor.
What mass of sulfuric acid is needed to completely react with 1000 dm^3 of ammonia?
(One mole of gas occupies 24 dm^3 at room temperature and pressure.)

[3]

(c) Ammonium sulfate is sold as a solid fertiliser

(i) Describe how solid ammonium sulfate can be separated from the reaction mixture formed in process 2.

____

____ [2]

(ii) The percentage yield of ammonium sulfate in process 2 is lower than in process 1.
Suggest a reason why.

____ [1]

[Total: 10]

The Periodic Table of Elements

Key: proton (atomic) number / atomic symbol / name / relative atomic mass

I	II	Group										III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).