



Cambridge O Level

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CHEMISTRY

5070/22

Paper 2 Theory

October/November 2024

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

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2

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1 (a) Fig. 1.1 shows the electronic configurations of five atoms, **A**, **B**, **C**, **D** and **E**.

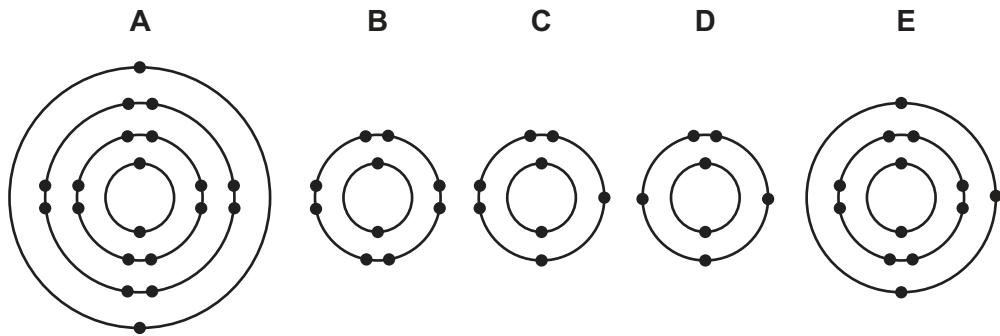


Fig. 1.1

Answer the questions about these electronic configurations.

Each electronic configuration may be used once, more than once or not at all.

State which electronic configuration, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom of a noble gas

..... [1]

(ii) an atom of an element that is used in food containers because of its resistance to corrosion

..... [1]

(iii) an atom of an element in Group V of the Periodic Table

..... [1]

(iv) an atom of an element in Period 3 of the Periodic Table

..... [1]

(v) an atom that forms a stable ion with a charge of 2-.

..... [1]

(b) Deduce the number of protons and neutrons in the vanadium atom shown.



number of protons

number of neutrons

[2]

[Total: 7]





2 Iron is extracted in the blast furnace by the reduction of iron(III) oxide, Fe_2O_3 .

This process is made up of three steps.

(a) (i) In step 1, carbon burns in air to produce carbon dioxide.

Give one **other** reason why carbon is burned in air in the blast furnace.

..... [1]

(ii) In step 2, carbon monoxide is produced by the reaction of carbon dioxide with carbon.

State **one** adverse effect of carbon monoxide on health.

..... [1]

(iii) In step 3, iron(III) oxide is reduced by carbon monoxide.

Write the symbol equation for this reaction.

..... [1]

(b) Explain why calcium carbonate is added to the blast furnace.

Include any relevant reactions or equations in your answer.

.....
.....
..... [2]

(c) Iron is a transition element.

Transition elements have high melting and boiling points.

State two **other** properties that are typical of transition elements but **not** of Group I metals.

1

2

[2]

(d) Iron is prevented from rusting by galvanising with zinc.

Explain **two** different ways in which zinc prevents rusting.

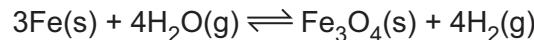
.....
.....
.....
..... [3]





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(e) The equation shows the reaction of iron with steam in a closed container.



Predict and explain what happens to the position of equilibrium when the pressure is increased. The temperature remains the same.

prediction

explanation

.....

[2]

(f) Fe_3O_4 reacts with concentrated hydrochloric acid.

The products are iron(II) chloride, iron(III) chloride and a liquid that turns blue cobalt(II) chloride paper pink.

Construct the symbol equation for this reaction.

..... [2]

[Total: 14]





3 Fig. 3.1 shows the apparatus used for the electrolysis of dilute sulfuric acid using graphite electrodes.

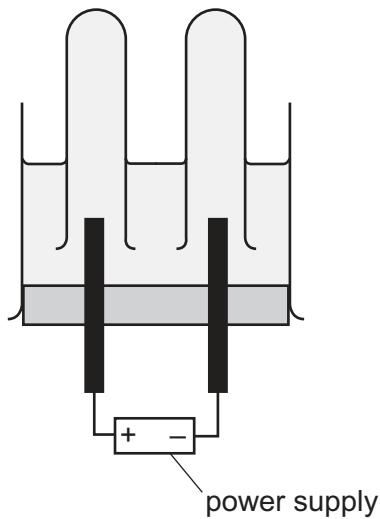


Fig. 3.1

(a) Define the term electrolysis.

..... [2]

(b) Label the anode on Fig. 3.1. [1]

(c) (i) Name the product at the cathode.

..... [1]

(ii) Oxygen is formed at the anode.

Construct the ionic half-equation for the reaction at the anode.

..... [1]

(d) Name a suitable element other than graphite that is used for the electrodes in this electrolysis.

..... [1]

[Total: 6]





4 This question is about alkanes and alkenes.

(a) Butane belongs to the alkane homologous series.

Members of the same homologous series have the same functional group and the same general formula.

State two **other** characteristics of a homologous series.

1

2

[2]

(b) Fig. 4.1 shows the displayed formula of butane.

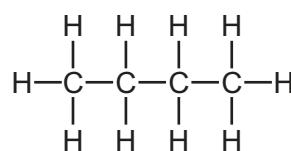


Fig. 4.1

(i) Explain how Fig. 4.1 shows that butane is a saturated compound.

..... [1]

(ii) Give the structural formula of butane.

..... [1]

(c) Nonane, C_9H_{20} , is present in the naphtha fraction from the distillation of petroleum.

(i) State **one** use of the naphtha fraction.

..... [1]

(ii) When nonane is cracked, shorter hydrocarbon molecules are formed.

Construct the symbol equation for a reaction in which nonane is cracked and the only products are propane and ethene.

..... [2]





(d) Propane reacts with chlorine in the presence of ultraviolet light.

Fig. 4.2 shows the displayed formulae of the reactants and products.

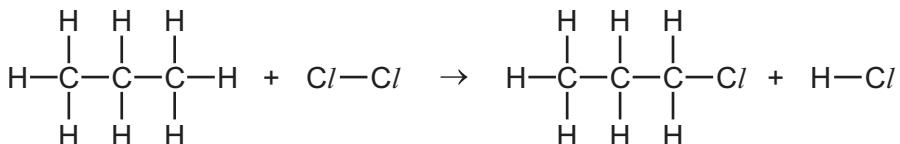


Fig. 4.2

(i) Name the type of chemical reaction that takes place.

..... [1]

(ii) State the purpose of the ultraviolet light in this reaction.

..... [1]

(iii) Calculate the enthalpy change of this reaction in kJ/mol.

Use the bond energies in Table 4.1.

Table 4.1

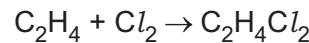
type of bond	C–C	C–H	Cl–Cl	C–Cl	H–Cl
bond energy in kJ/mol	347	413	243	346	432

enthalpy change = kJ/mol
[3]





(e) The equation shows the reaction of ethene with chlorine.



Explain how this equation shows that this reaction is an addition reaction.

.....
.....

[1]

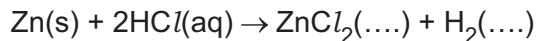
[Total: 13]





5 A student adds large pieces of zinc to dilute hydrochloric acid. The zinc is in excess.

(a) Complete the equation by adding state symbols for the products.



[1]

(b) Fig. 5.1 shows how the volume of hydrogen changes with time as the reaction proceeds.

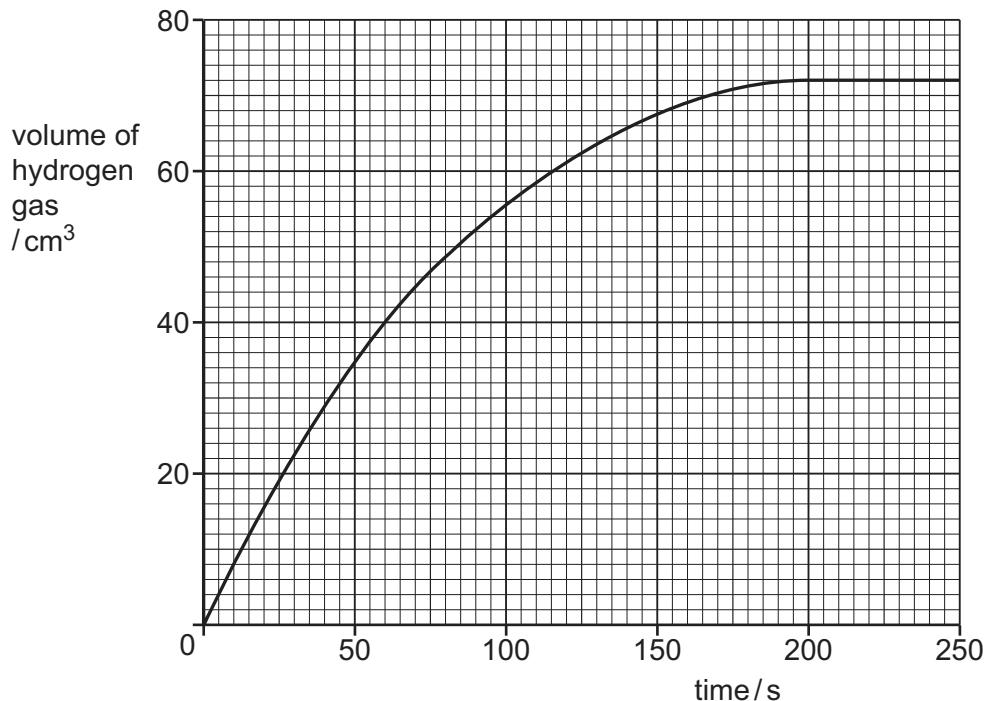


Fig. 5.1

(i) Describe how the shape of the curve in Fig. 5.1 shows that the rate of reaction decreases with time.

.....

 [1]

(ii) Explain in terms of collision theory why the rate of reaction decreases with time.

.....

 [2]





(iii) The student repeats the experiment using the same mass of powdered zinc instead of large pieces of zinc. All other conditions stay the same.

Describe and explain the difference in rate of reaction when powdered zinc is used.

.....
.....
.....

[2]

(c) Excess zinc is added to 16.0 cm^3 of 0.400 mol/dm^3 hydrochloric acid.

Calculate the volume of hydrogen gas released measured at room temperature and pressure.

Give your answer to **two** significant figures.

volume of hydrogen gas = dm^3 [3]





(d) The reaction of zinc with hydrochloric acid is exothermic.

Complete the reaction pathway diagram in Fig. 5.2 to show:

- the reactants and products
- a labelled arrow for the activation energy, E_a
- a labelled arrow for the enthalpy change, ΔH .

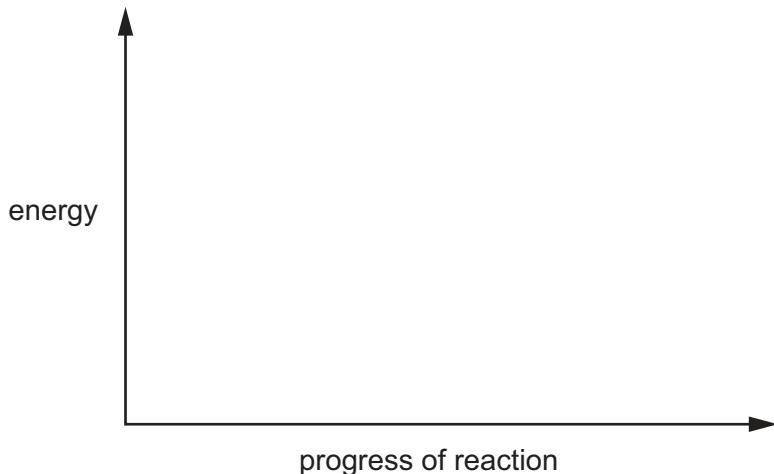


Fig. 5.2

[3]

(e) Describe the observations made when:

- a few drops of aqueous ammonia are added to an aqueous solution containing zinc ions

.....

- excess aqueous ammonia is added to an aqueous solution containing zinc ions.

.....

[2]

(f) Describe how to prepare pure, dry crystals of zinc chloride after reacting excess zinc with dilute hydrochloric acid.

.....

.....

.....

.....

[3]

[Total: 17]





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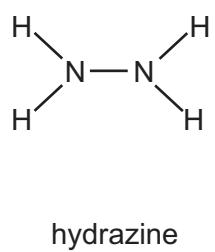
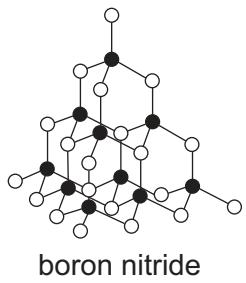
Question 6 starts on page 14.





6 Fig. 6.1 shows the structures of boron nitride and hydrazine.

Boron nitride has a structure similar to diamond.



Key :

- boron atoms
- nitrogen atoms

Fig. 6.1

(a) Explain why boron nitride has a high melting point.

Use the information in Fig. 6.1.

.....
.....
..... [2]

(b) Explain why hydrazine is a poor electrical conductor.

Use the information in Fig. 6.1.

..... [1]

(c) Complete Fig. 6.2 to show the dot-and-cross diagram for the electronic configuration of hydrazine.

Show only the outer shell electrons.

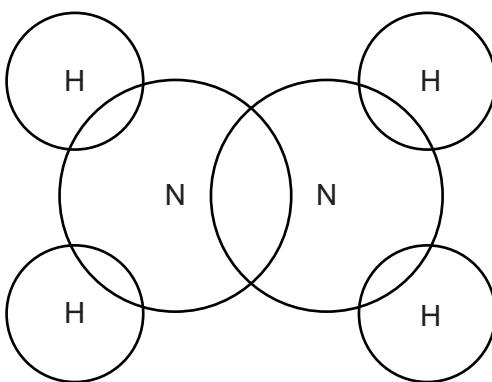


Fig. 6.2

[1]





(d) The ionic equation for the reaction of nitride ions with water is shown.



(i) The oxidation number of hydrogen in NH_3 is +1.

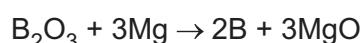
Deduce the oxidation number of nitrogen in NH_3 .

..... [1]

(ii) Explain why this is **not** a redox reaction by referring to the oxidation number of nitrogen.

..... [1]

(e) Boron oxide reacts with magnesium as shown.



8.0 g of boron oxide is reacted with 7.2 g of magnesium.

Show by calculation that boron oxide is in excess.

[3]

[Total: 9]





7 Esters are represented by the formula $C_nH_{2n}O_2$.

(a) (i) State the name given to a formula such as $C_nH_{2n}O_2$.

..... [1]

(ii) Deduce the value of n in the ester propyl ethanoate.

..... [1]

(b) The ester ethyl butanoate is produced by reacting ethanol with butanoic acid.

Draw the displayed formula of ethyl butanoate.

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[1]

(c) Fig. 7.1 shows the simplified structures of two molecules that combine to form a polyester.

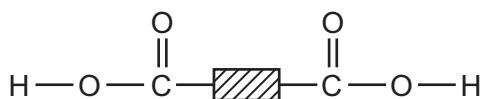


Fig. 7.1

(i) Complete the diagram in Fig. 7.2 to show the structure of two repeat units of this polyester.

Show all of the atoms and all of the bonds in the linkages.



Fig. 7.2

[3]



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(ii) Name the type of polymerisation in this reaction.

..... [1]

(d) PET is a plastic.

Describe the chemical processes involved in converting used PET into a new plastic.

..... [2]

(e) Ethanoic acid reacts with sodium carbonate.

(i) Name the three products of this reaction.

1

2

3

[3]

(ii) Ethanoic acid is a liquid at room temperature.

Describe the arrangement and motion of the particles in a liquid.

arrangement

.....

motion

.....

[2]

[Total: 14]







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The Periodic Table of Elements

Group		Group																						
		I			II			III			IV			V			VI			VII				
3	4	Li lithium 7	Be beryllium 9					H hydrogen 1																
11	12	Na sodium 23	Mg magnesium 24																					
19	20	K potassium 39	Ca calcium 40	Sc scandium 45	Ti titanium 48	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59	Cu copper 64	Zn zinc 65	Ge germanium 73	As arsenic 75	Se selenium 79	Br bromine 80	Kr krypton 84						
37	38	Rb rubidium 85	Sr strontium 88	Y yttrium 89	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium –	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106	Ag silver 108	Cd cadmium 112	In indium 115	Sn tin 119	Te antimony 122	I iodine 128	Xe xenon 131						
55	56	Cs caesium 133	Ba barium 137	La lanthanoids 139	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Tl thallium 204	Hg mercury 201	Pb lead 207	Bi bismuth 209	Po polonium –	Rn radon –	At astatine –	Fr francium –	Ra radium –	Mc moscovium –	Ts tennessine –	Og oganesson –
87	88				Rf actinoids –	Db rutherfordium –	Sg seaborgium –	Bh bohrium –	Hs hassium –	Mt meitnerium –	Ds darmstadtium –	Rg roentgenium –	Cn copernicium –	Fl flerovium –	Lv livermorium –	Md merdelevium –	Yb ytterbium 173	Lu lutetium 175						

Key

atomic number	atomic symbol
name	
relative atomic mass	

Group

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	8010	8011	8012	8013	8014	8015	8016	8017	8018	8019	8020	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035	8036	8037	8038	8039	8040	8041	8042	8043	8044	8045	8046	8047	8048	8049	8050	8051	8052	8053	8054	8055	8056	8057	8058	8059	8060	8061	8062	8063	8064	8065	8066	8067	8068	8069	8070	8071	8072	8073	8074	8075	8076	8077	8078	8079	8080	8081	8082	8083	8084	8085	8086	8087	8088	8089	8090	8091	8092	8093	8094	8095	8096	8097	8098	8099	80100	80101	80102	80103	80104	80105	80106	80107	80108	80109	80110	80111	80112	80113	80114	80115	80116	80117	80118	80119	80120	80121	80122	80123	80124	80125	80126	80127	80128	80129	80130	80131	80132	80133	80134	80135	80136	80137	80138	80139	80140	80141	80142	80143	80144	80145	80146	80147	80148	80149	80150	80151	80152	80153	80154	80155	80156	80157	80158	80159	80160	80161	80162	80163	80164	80165	80166	80167	80168	80169	80170	80171	80172	80173	80174	80175	80176	80177	80178	80179	80180	80181	80182	80183	80184	80185	80186	80187	80188	80189	80190	80191	80192	80193	801