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**Chemistry**  
**Higher level**  
**Paper 1**

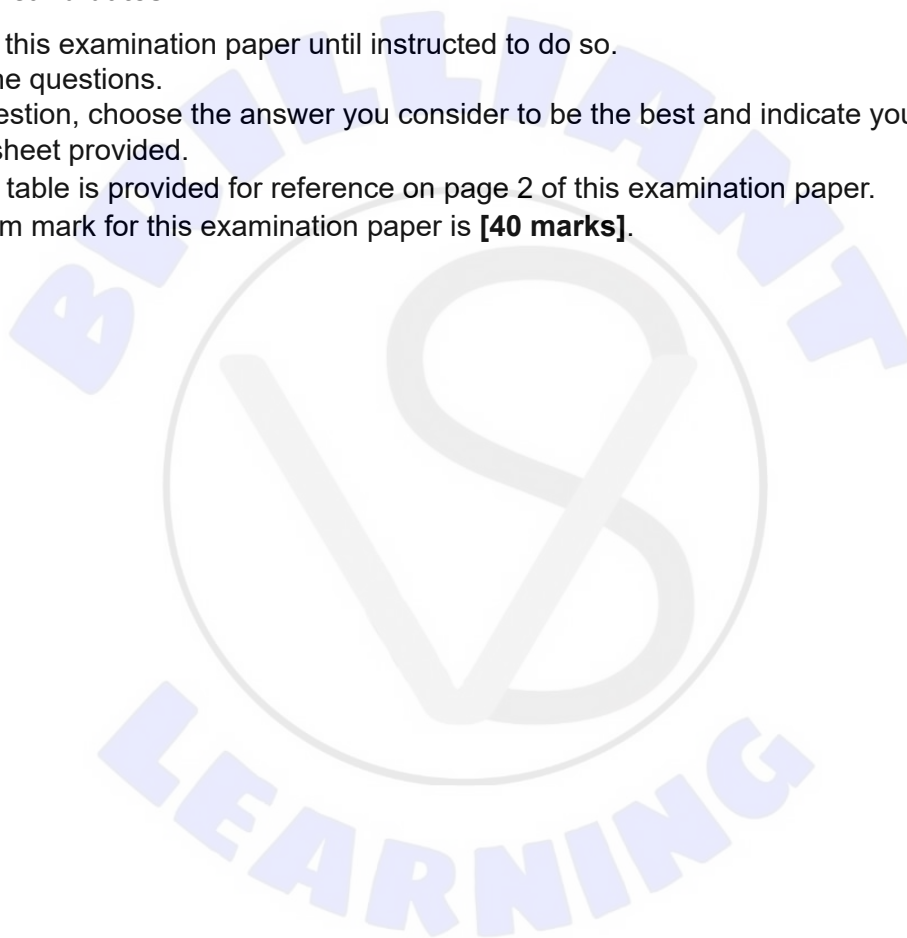
Wednesday 22 May 2019 (afternoon)

1 hour

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**Instructions to candidates**

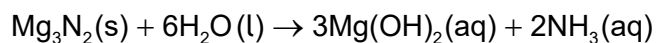
- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The periodic table is provided for reference on page 2 of this examination paper.
- The maximum mark for this examination paper is **[40 marks]**.



### The Periodic Table

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																										
1	1 <b>H</b> 1.01	Atomic number		Element																																								
2	3 <b>Li</b> 6.94	4 <b>Be</b> 9.01	Relative atomic mass																																									
3	11 <b>Na</b> 22.99	12 <b>Mg</b> 24.31	13 <b>Al</b> 26.98	14 <b>Si</b> 28.09	15 <b>P</b> 30.97	16 <b>S</b> 32.07	17 <b>Cl</b> 35.45	18 <b>Ar</b> 39.95	19 <b>K</b> 39.10	20 <b>Ca</b> 40.08	21 <b>Sc</b> 44.96	22 <b>Ti</b> 47.87	23 <b>V</b> 50.94	24 <b>Cr</b> 52.00	25 <b>Mn</b> 54.94	26 <b>Fe</b> 55.85	27 <b>Co</b> 58.93	28 <b>Ni</b> 58.69	29 <b>Cu</b> 63.55	30 <b>Zn</b> 65.38	31 <b>Ga</b> 69.72	32 <b>Ge</b> 72.63	33 <b>As</b> 74.92	34 <b>Se</b> 78.96	35 <b>Br</b> 79.90	36 <b>Kr</b> 83.90	37 <b>Rb</b> 85.47	38 <b>Sr</b> 87.62	39 <b>Y</b> 88.91	40 <b>Zr</b> 91.22	41 <b>Nb</b> 92.91	42 <b>Mo</b> 95.96	43 <b>Tc</b> (98)	44 <b>Ru</b> 101.07	45 <b>Rh</b> 102.91	46 <b>Pd</b> 106.42	47 <b>Ag</b> 107.87	48 <b>Cd</b> 112.41	49 <b>In</b> 114.82	50 <b>Sn</b> 118.71	51 <b>Sb</b> 121.76	52 <b>Te</b> 127.60	53 <b>I</b> 126.90	54 <b>Xe</b> 131.29
4	55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57† <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)																										
5	87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89‡ <b>Ac</b> (227)	104 <b>Rf</b> (267)	105 <b>Db</b> (268)	106 <b>Sg</b> (269)	107 <b>Bh</b> (270)	108 <b>Hs</b> (269)	109 <b>Mt</b> (278)	110 <b>Ds</b> (281)	111 <b>Rg</b> (281)	112 <b>Cn</b> (285)	113 <b>Uut</b> (286)	114 <b>Uug</b> (289)	115 <b>Uup</b> (288)	116 <b>Uuh</b> (293)	117 <b>Uus</b> (294)	118 <b>Uuo</b> (294)																										
6	55 <b>Cs</b> 132.91	56 <b>Ba</b> 137.33	57† <b>La</b> 138.91	72 <b>Hf</b> 178.49	73 <b>Ta</b> 180.95	74 <b>W</b> 183.84	75 <b>Re</b> 186.21	76 <b>Os</b> 190.23	77 <b>Ir</b> 192.22	78 <b>Pt</b> 195.08	79 <b>Au</b> 196.97	80 <b>Hg</b> 200.59	81 <b>Tl</b> 204.38	82 <b>Pb</b> 207.2	83 <b>Bi</b> 208.98	84 <b>Po</b> (209)	85 <b>At</b> (210)	86 <b>Rn</b> (222)																										
7	87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89‡ <b>Ac</b> (227)	104 <b>Rf</b> (267)	105 <b>Db</b> (268)	106 <b>Sg</b> (269)	107 <b>Bh</b> (270)	108 <b>Hs</b> (269)	109 <b>Mt</b> (278)	110 <b>Ds</b> (281)	111 <b>Rg</b> (281)	112 <b>Cn</b> (285)	113 <b>Uut</b> (286)	114 <b>Uug</b> (289)	115 <b>Uup</b> (288)	116 <b>Uuh</b> (293)	117 <b>Uus</b> (294)	118 <b>Uuo</b> (294)																										
	†	58 <b>Ce</b> 140.12	59 <b>Pr</b> 140.91	60 <b>Nd</b> 144.24	61 <b>Pm</b> (145)	62 <b>Sm</b> 150.36	63 <b>Eu</b> 151.96	64 <b>Gd</b> 157.25	65 <b>Tb</b> 158.93	66 <b>Dy</b> 162.50	67 <b>Ho</b> 164.93	68 <b>Er</b> 167.26	69 <b>Tm</b> 168.93	70 <b>Yb</b> 173.05	71 <b>Lu</b> 174.97																													
	‡	90 <b>Th</b> 232.04	91 <b>Pa</b> 231.04	92 <b>U</b> 238.03	93 <b>Np</b> (237)	94 <b>Pu</b> (244)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (251)	99 <b>Es</b> (252)	100 <b>Fm</b> (257)	101 <b>Md</b> (258)	102 <b>No</b> (259)	103 <b>Lr</b> (262)																													

1. How many moles of magnesium hydroxide are produced with 0.50 mol of ammonia?



- A. 0.25  
 B. 0.33  
 C. 0.75  
 D. 1.5
2. What is the sum of the integer coefficients when propene undergoes complete combustion?



- A. 11  
 B. 17  
 C. 21  
 D. 23
3. What is the volume of gas when the pressure on 100 cm<sup>3</sup> of gas is changed from 400 kPa to 200 kPa at constant temperature?
- A. 50.0 cm<sup>3</sup>  
 B. 100 cm<sup>3</sup>  
 C. 200 cm<sup>3</sup>  
 D. 800 cm<sup>3</sup>
4. Which is correct for  ${}^{34}_{16}\text{S}^{2-}$ ?

	Protons	Neutrons	Electrons
A.	16	18	14
B.	18	16	18
C.	16	18	16
D.	16	18	18

Turn over

5. Which of the following transitions in the hydrogen atom emits the least energy?
- A.  $n = 2$  to  $n = 1$
  - B.  $n = 3$  to  $n = 1$
  - C.  $n = 4$  to  $n = 2$
  - D.  $n = 4$  to  $n = 3$

6. How is colour produced in transition metal complexes?
- A. Light is absorbed when electrons are promoted between split d-orbitals.
  - B. Light is emitted when electrons fall between split d-orbitals.
  - C. Light is absorbed when electrons escape from the complex.
  - D. Light is emitted when the complex returns to ground state.

7. How do the following properties change down Group 17 of the periodic table?

	<b>Ionization energy</b>	<b>Ionic radius</b>
A.	increases	decreases
B.	increases	increases
C.	decreases	increases
D.	decreases	decreases

8. What is the oxidation state of the metal ion and charge of the complex ion in  $[\text{Co}(\text{NH}_3)_4\text{Cl}_2]\text{Cl}$ ?

	<b>Oxidation state of metal ion</b>	<b>Charge of complex ion</b>
A.	+1	2+
B.	+2	1+
C.	+3	1+
D.	+3	0

9. How does a lithium atom form the most stable ion?
- A. The atom gains a proton to form a positive ion.
  - B. The atom loses a proton to form a negative ion.
  - C. The atom loses an electron to form a positive ion.
  - D. The atom gains an electron to form a negative ion.

10. Which combination causes the strength of metallic bonding to increase?

	Charge on cations	Ionic radius
A.	smaller	smaller
B.	larger	larger
C.	smaller	larger
D.	larger	smaller

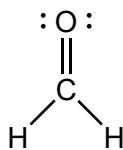
11. Which species has a square planar molecular geometry?

- A.  $\text{SF}_4$
- B.  $\text{XeF}_4$
- C.  $\text{CF}_4$
- D.  $\text{PF}_4^+$

12. How many sigma ( $\sigma$ ) and pi ( $\pi$ ) bonds are present in hydrogen cyanide, HCN?

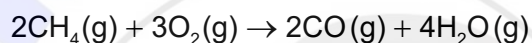
	Sigma ( $\sigma$ )	Pi ( $\pi$ )
A.	1	1
B.	2	2
C.	2	1
D.	1	3

13. What is the hybridization of carbon and oxygen in methanal?



	Hybridization of C	Hybridization of O
A.	$sp^2$	$sp^2$
B.	$sp^2$	$sp$
C.	$sp$	$sp^2$
D.	$sp^3$	$sp^3$

14. Methane undergoes incomplete combustion.

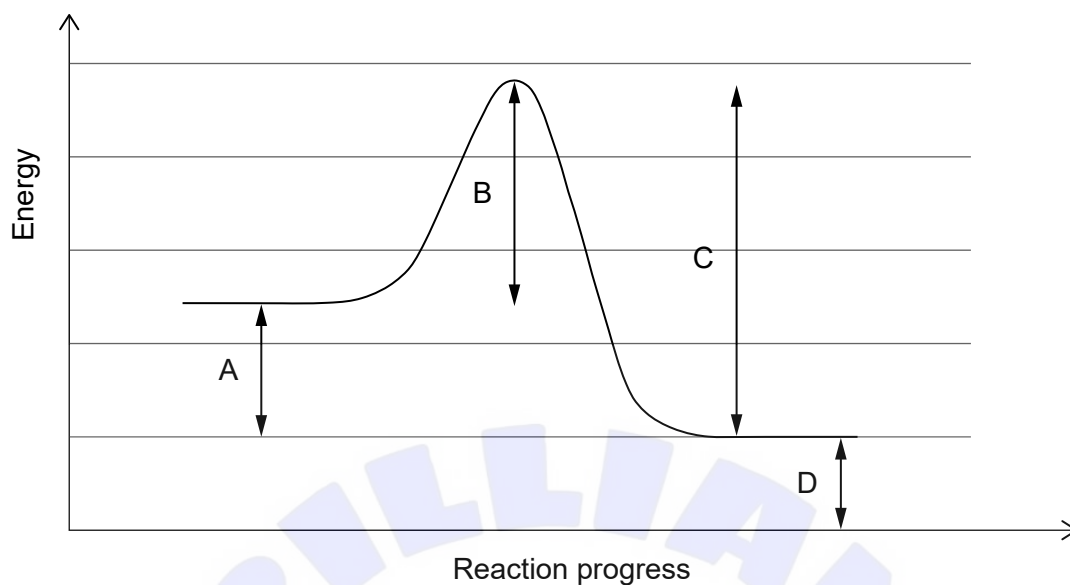


What is the enthalpy change, in kJ, using the bond enthalpy data given below?

Bond	Average bond enthalpy / $\text{kJ mol}^{-1}$
C-H	414
O-H	463
O=O	498
$\text{C}\equiv\text{O}$	1077

- A.  $[2(1077) + 4(463)] - [2(414) + 3(498)]$   
 B.  $[2(414) + 3(498)] - [2(1077) + 4(463)]$   
 C.  $[8(414) + 3(498)] - [2(1077) + 8(463)]$   
 D.  $[2(1077) + 8(463)] - [8(414) + 3(498)]$

15. What is the activation energy of the reverse reaction?



16. Which equation represents lattice enthalpy?

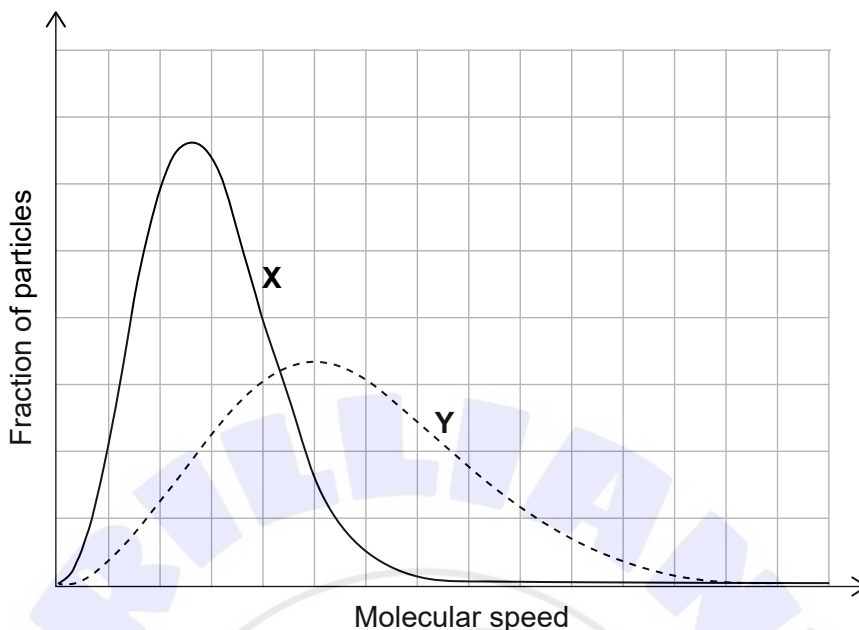
- A.  $\text{NaCl}(\text{g}) \rightarrow \text{Na}^+(\text{g}) + \text{Cl}^-(\text{g})$
- B.  $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{g}) + \text{Cl}^-(\text{g})$
- C.  $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- D.  $\text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{s}) + \text{Cl}^-(\text{s})$

17. Which change has the greatest increase in entropy?

- A.  $\text{CO}_2(\text{s}) \rightarrow \text{CO}_2(\text{g})$
- B.  $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{l})$
- C.  $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$
- D.  $\text{CO}_2(\text{l}) \rightarrow \text{CO}_2(\text{s})$

Turn over

18. The same amount of two gases, **X** and **Y**, are in two identical containers at the same temperature. What is the difference between the gases?



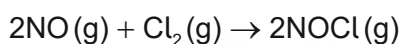
- A. **X** has the higher molar mass.  
 B. **Y** has the higher molar mass.  
 C. **X** has the higher average kinetic energy.  
 D. **Y** has the higher average kinetic energy.
19. Several reactions of calcium carbonate with dilute hydrochloric acid are carried out at the same temperature.



Which reaction has the greatest rate?

	Concentration of HCl (aq)	Surface area of same mass of CaCO <sub>3</sub> (s)
A.	higher	larger
B.	lower	smaller
C.	lower	larger
D.	higher	smaller

20. Which statement is correct about a catalyst?
- A. It decreases the activation energy of the forward reaction but not the reverse.
  - B. It increases the proportion of products to reactants in an equilibrium.
  - C. It decreases the enthalpy change of the reaction.
  - D. It changes the mechanism of the reaction.
21. What is the order with respect to each reactant?



Initial [NO] / mol dm <sup>-3</sup>	Initial [Cl <sub>2</sub> ] / mol dm <sup>-3</sup>	Initial rate / mol dm <sup>-3</sup> s <sup>-1</sup>
0.10	0.10	2.5 × 10 <sup>-6</sup>
0.10	0.20	5.0 × 10 <sup>-6</sup>
0.20	0.10	10.0 × 10 <sup>-6</sup>

	Order with respect to NO	Order with respect to Cl <sub>2</sub>
A.	0	1
B.	1	1
C.	2	1
D.	2	2

22. Consider the following equilibrium reaction.

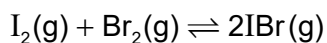


Which change will move the equilibrium to the right?

- A. Decrease in pressure
- B. Decrease in temperature
- C. Increase in [NO]
- D. Decrease in [O<sub>2</sub>]

Turn over

23. Iodine and bromine gases were mixed and allowed to reach equilibrium.

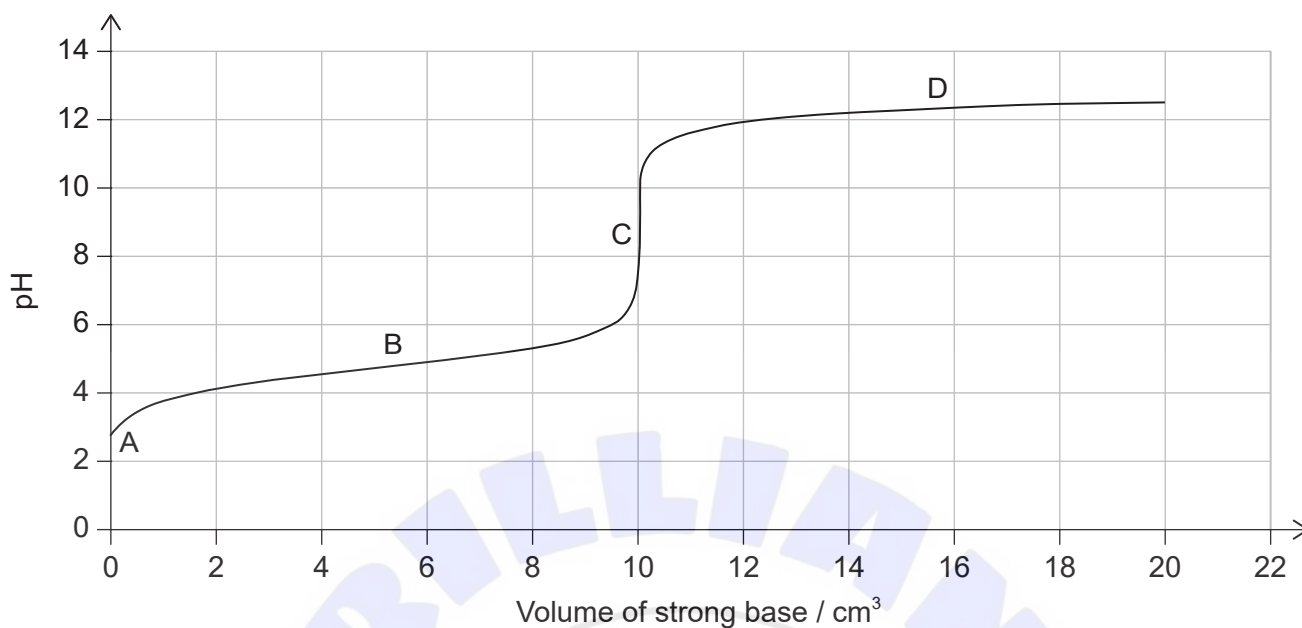


	<b>[I<sub>2</sub>]</b>	<b>[Br<sub>2</sub>]</b>	<b>[IBr]</b>
Initial concentration	0.20	0.20	0.00
Equilibrium concentration	0.10	0.10	<i>x</i>

What is the value of the equilibrium constant?

- A. 0.05  
B. 1  
C. 4  
D. 10
24. What is the pH of 0.001 mol dm<sup>-3</sup> NaOH(aq)?
- A. 1  
B. 3  
C. 11  
D. 13
25. What is the major reason why the pH of unpolluted rain is less than 7?
- A. methane  
B. carbon dioxide  
C. nitrogen oxides  
D. sulfur dioxide

26. Where is the buffer region for the titration of a weak acid with a strong base?



27. The following equation represents the dissociation of water at 25 °C.

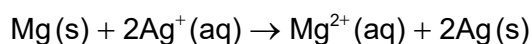


Which changes occur as the temperature increases?

- A.  $[\text{H}_3\text{O}^+]$  increases and pH will decrease.
  - B.  $[\text{H}_3\text{O}^+]$  decreases and pH will increase.
  - C.  $[\text{H}_3\text{O}^+]$  increases and pH will increase.
  - D.  $[\text{H}_3\text{O}^+]$  decreases and pH will decrease.
28. Which compound contains sulfur with an oxidation state of +6?
- A.  $\text{SO}_2$
  - B.  $\text{H}_2\text{S}$
  - C.  $\text{H}_2\text{SO}_3$
  - D.  $\text{H}_2\text{SO}_4$

Turn over

29. The following reaction occurs in a voltaic (galvanic) cell.



Which reaction takes place at each electrode?

	<b>Anode (negative electrode)</b>	<b>Cathode (positive electrode)</b>
A.	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg(s)}$
B.	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$	$\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$
C.	$\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$	$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag(s)}$
D.	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg(s)}$	$\text{Ag(s)} \rightarrow \text{Ag}^+(\text{aq}) + \text{e}^-$

30. Consider the following table of standard electrode potentials.

<b>Reaction</b>	<b><math>E^\ominus / \text{V}</math></b>
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightleftharpoons \text{Al(s)}$	-1.66
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Pb(s)}$	-0.13

Which is the strongest oxidizing agent?

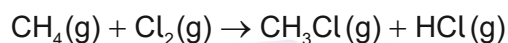
- A.  $\text{Pb}^{2+}$   
 B. Pb  
 C.  $\text{Al}^{3+}$   
 D. Al
31. What are the products when concentrated  $\text{KBr(aq)}$  is electrolysed?

	<b>Anode (positive electrode)</b>	<b>Cathode (negative electrode)</b>
A.	$\text{O}_2$	K
B.	$\text{O}_2$	$\text{H}_2$
C.	$\text{Br}_2$	K
D.	$\text{Br}_2$	$\text{H}_2$

32. Which compound has the lowest boiling point?

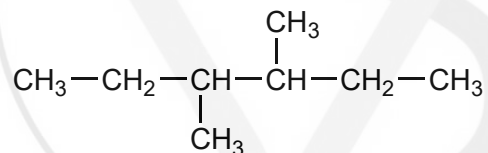
- A.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- B.  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
- C.  $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{CH}_3$
- D.  $\text{CH}_3\text{C}(\text{CH}_3)_2\text{CH}_3$

33. Methane reacts with chlorine in sunlight.



Which type of reaction occurs?

- A. free-radical substitution
  - B. electrophilic substitution
  - C. nucleophilic substitution
  - D. electrophilic addition
34. What is the name of this compound using IUPAC rules?



- A. 2,3-diethylbutane
- B. 2-ethyl-3-methylpentane
- C. 3-methyl-4-ethylpentane
- D. 3,4-dimethylhexane

Turn over

35. What must be present on a nucleophile?
- A. Negative charge
  - B. Lone pair of electrons
  - C. Positive charge
  - D. Symmetrical distribution of electrons
36. Which compound exists as two configurational isomers?
- A.  $\text{CBr}_2=\text{CH}_2$
  - B.  $\text{CH}_2=\text{CHBr}$
  - C.  $\text{CHBr}_2\text{CH}_2\text{Br}$
  - D.  $\text{CHBr}=\text{CHBr}$
37. Which class of compound is formed when a ketone is reduced?
- A. primary alcohol
  - B. secondary alcohol
  - C. ether
  - D. carboxylic acid
38. The following data were recorded for determining the density of three samples of silicon, Si.

Mass / g $\pm 0.01 \text{ g}$	Volume / $\text{cm}^3$ $\pm 0.1 \text{ cm}^3$
5.61	2.8
4.32	1.7
6.37	2.8

Which average density value, in  $\text{g cm}^{-3}$ , has been calculated to the correct number of significant figures?

- A. 2
- B. 2.3
- C. 2.27
- D. 2.273

39. What can be deduced from the infrared (IR) spectrum of a compound?
- A. Number of hydrogens
  - B. Number of hydrogen environments
  - C. Bonds present
  - D. Molar mass
40. Which technique involves breaking covalent bonds when carried out on an organic compound?
- A. infrared spectroscopy
  - B. nuclear magnetic resonance spectroscopy
  - C. X-ray crystallography
  - D. mass spectrometry
- 

