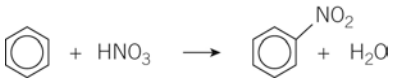
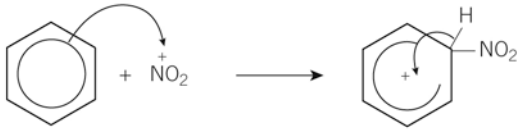
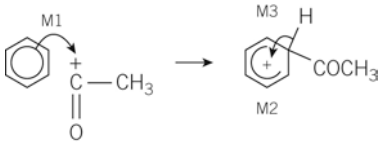
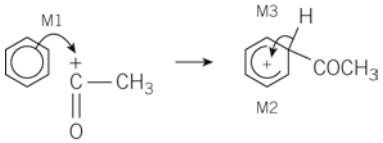
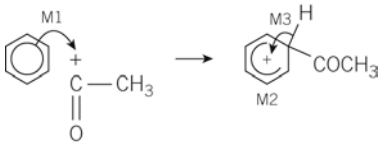
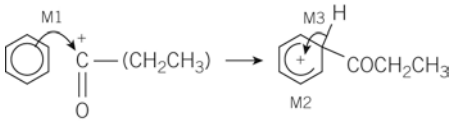
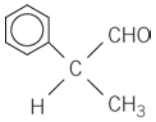
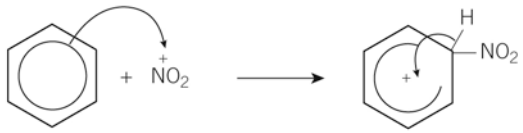
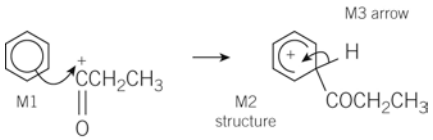
Question number	Answer	Marks	Guidance
1	conc HNO_3 conc H_2SO_4 $HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ or $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_2O + HSO_4^-$ or $HNO_3 + H^+ \rightarrow NO_2^+ + H_2O$  Electrophilic substitution  	1 1 1 1 1 3	If both 'conc' missing you can score one for both acids. This can also be done in two equations. Benzene can also be written as C_6H_6 and nitrobenzene as $C_6H_5NO_2$. One mark is for the arrow from within hexagon to N or to the + on N (M1). The 'horseshoe' must not extend beyond C2 to C6. (M2) Mark 3 is for the arrow into the hexagon (M3).
2	$CH_3COCl + AlCl_3 \rightarrow CH_3^+CO + AlCl_4^-$ Electrophilic substitution  	2 1 3	One mark is for the correct reactive species and one for the equation. This cannot be F/C acylation. Horseshoe must not extend beyond C2 to C6. The + must be on the C of RC^+O.
3	$CH_3COCl + AlCl_3 \rightarrow CH_3^+CO + AlCl_4^-$  Electrophilic substitution	2 3 1	There is no mark for the acylium ion here. The mark is for the aluminium chloride and the second mark is for the balanced equation. You could have $FeCl_3$. The position of + on electrophile can be on O or C. The M1 arrow from within hexagon to C or to + on C. The + must be on C of RCO. This is not F/C acylation.

4 (a)	CH_3CO^+	1	
4 (b)		3	Horseshoe must not extend beyond C2 to C6. The + must be on the C of RC^+O.
5 (a)	CH_3CH_2COCl **OR** CH_3CH_2CClO **OR** propanoyl chloride OR $(CH_3CH_2CO)_2O$ **OR** propanoic anhydride penalize contradiction in formula and name, e.g., propyl chloride $AlCl_3$ or $FeCl_3$ or names $CH_3CH_2COCl + AlCl_3 \rightarrow CH_3CH_2CO^+ + AlCl_4^-$ Allow RCOCl in equation but penalise above	1 1 1	could score in equation could score in equation allow + on C or O in equation
5 (b)		3	M1 arrow from circle or within it to C or to + on C Horseshoe must not extend beyond C2 to C6 but can be smaller + not too close to C1 M3 arrow into hexagon unless Kekule allow M3 arrow independent of M2 structure Ignore base removing H in M3
5 (c)	Tollens or ammoniacal silver nitrate 	1 1	penalise wrong formula
6 (a)	Benzene is <u>more stable than cyclohexatriene</u> Expected $\Delta H^{\ominus}_{hydrogenation}$ of C_6H_6 is 3(–120) = –360 kJ mol^{-1} Actual $\Delta H^{\ominus}_{hydrogenation}$ of benzene is 152 kJ mol^{-1} (less exothermic) or 152 kJ mol^{-1} different from expected Because of delocalisation or electrons spread out or resonance	1 1 1 1	more stable than cyclohexatriene must be stated or implied If benzene more stable than cyclohexene, then penalise M1 but mark on If benzene less stable: can score M2 only Allow in words e.g. expected $\Delta H^{\ominus}_{hydrog}$ is three times the $\Delta H^{\ominus}_{hydrog}$ of cyclohexene Ignore energy needed

6 (b)	Conc HNO_3 Conc H_2SO_4 $2\ H_2SO_4 + HNO_3 \rightarrow 2\ HSO_4^- + NO_2^+ + H_3O^+$ OR $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + NO_2^+ + H_2O$ OR via two equations $H_2SO_4 + HNO_3 \rightarrow HSO_4^- + H_2NO_3^+$ $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$  	1 1 1 3	If either or both conc missing, allow one; this one mark can be gained in equation Allow + anywhere on NO_2^+ M1 arrow from within hexagon to N or + on N Allow NO_2^+ in mechanism horseshoe must not extend beyond C2 to C6 but can be smaller + not too close to C1 M3 arrow into hexagon unless Kekule allow M3 arrow independent of M2 structure ignore base removing H in M3 + on H in intermediate loses M2 not M3
7	$[CH_3CH_2CO]^+$ $CH_3CH_2COCl + AlCl_3 \rightarrow$ $[CH_3CH_2CO]^+ + AlCl_4^-$  	1 1 3	You can gain the electrophile mark from the equation if not stated separately. Therefore the correct balanced equation is worth 2 marks. In the equation, the position of the + can be on O or C or outside square brackets, however you do not need to show the square brackets. The arrow for M1 must be to C or to the + on C. The horseshoe should extend from C2 to C6 only.
8	Cyclohexane evolves 120 kJ mol^{-1} Therefore expect triene to evolve 360 kJ mol^{-1} ; or 3 × 120 = 360 kJ mol^{-1} 360 – 208 = 152 kJ; Benzene lower in energy / more stable; due to delocalisation;	4	Cannot estimate 150 kJ, you must use the values in the question. Therefore 152 kJ can score first 2 marks in this part. Any mention of 'bond breaking needing energy' will not score marks.
9 (a)	nitric acid and sulfuric acid	1	
9 (b)	explosives / dyes / fibres / pharmaceuticals	1	
9 (c) (i)	$C_6H_6 + HNO_3$ $\rightarrow C_6H_5NO_2 + H_2O$)	1 1	
9 (c) (ii)	it accepts a pair of electrons	1	
9 (c) (iii)	electrophilic substitution	1	