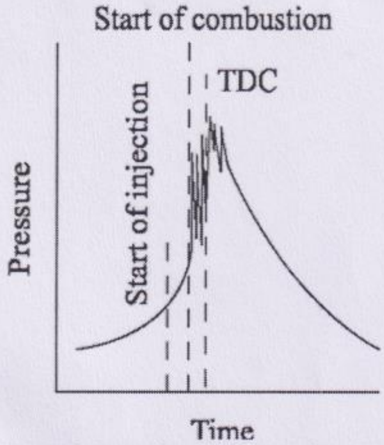
Solution/ marking scheme

Q.1 a)



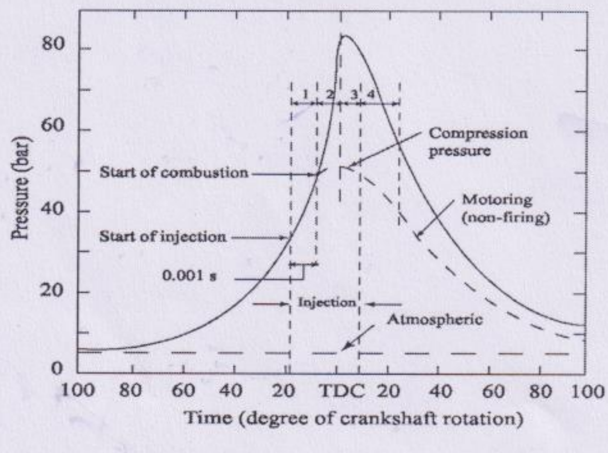
2 marks Diagram
2 marks Explanation

1. In S.I. engines detonation is caused by the auto-ignition of end gas towards the end of combustion whereas knocking in CI engines is due to auto-ignition of the first charge at the start of combustion. Therefore, to avoid detonation in SI engines auto ignition of end gas has to be prevented, and in CI engines earlier possible auto ignition should occur.
2. The air fuel mixture that self ignites in SI engines is homogeneous. Due to this rate of pressure rise and hence intensity of detonation is substantial compared to CI engines, where there is no homogeneous air-fuel mixture present at the time of self-ignition.
3. Compression ratio must be limited in SI engines beyond which detonation would occur. But for CI engines higher the compression ratio, lesser is the ignition delay and lesser probability of detonation (or diesel knock) occurring.
4. Larger size of cylinder promotes detonation in SI engines whereas detonation in CI engines is reduced with the same. For this reason, engines with cylinder diameters larger than 250 mm are almost always of CI type.
5. Fuels found good to prevent detonation in SI engines have longer ignition delay time which proves to be poor for preventing knocking in CI engines. This means fuels having higher octane rating have poor cetane rating and vice-versa.

b)
i. Ignition Temperature of Fuel -> Low
ii. Inlet Temperature -> High
iii. Ignition Delay -> Short

2 marks each

b)



2 marks Diagram
4 marks Explanation

Stage – 1 → Ignition Lag / Delay Period

- Physical Delay
- Chemical Delay

Stage – 2 → Rapid or Uncontrolled Combustion

Stage – 3 → Controlled Combustion

Stage – 4 → After Burning

Q.2 **a)**

- Understand the performance parameters in evaluation of IC engine performance — 1 mark each
- Calculate the speed of IC engine, fuel consumption, air consumption, etc.
- Evaluate the exhaust smoke and exhaust emission
- Differentiate between the performance of SI engine and CI engines.

b) 2 marks for mep, 4 marks for effi^{n}.

Soln -

1) mep

$$mep = \frac{\text{area of indicator dig}}{\text{length of indicator dig}} \times \text{spring const}$$

$$= \frac{12}{6} \times 2.9$$

$$\therefore mep = 5.8 \text{ bar}$$

2) η_{mech}

$$i.p. = \frac{p_m L A n}{60}$$

$$= 5.8\times10^5 \times 0.45 \times \frac{\pi}{4}(0.3)^2 \times \frac{200}{2\times60}$$

$$\therefore i.p. = 30.748 \text{ kW}$$

$$b.p. = \frac{2\pi N T}{60} = \frac{2\pi N W R}{60}$$

$$= \frac{2\pi \times 200 \times 1860 \times 0.61}{60}$$

$$b.p. = 23.763 \text{ kW}$$

$$f.p. = i.p. - b.p.$$

$$= 30.748 - 23.763$$

$$= 6.985 \text{ kW}$$

$$\eta_{mech} = \frac{b.p.}{i.p.}$$

$$= \frac{23.763}{30.748}$$

$$\eta_{mech} = 77.28\ \%$$

b)	a) Heat supplied to the engine $= \dot{m}_f \times CV$ $= 4.166 \times 10^{-3} \times 42,000 \times 10^{3}$ $= 174972$ W $= 174.972$ kW b) Heat converted to bP $= 59.999$ kW c) Heat carried away by cooling water $= \dot{m}_w C_{pw} \Delta T$ $= 0.798 \times 4.19 \times 10^{3} \times (308.8 - 293.8)$ $= 50.1523$ kW d) Heat carried away by exhaust gases $= \dot{m}_g C_{pg} \Delta T$ $= (\dot{m}_a + \dot{m}_f) C_{pg} \Delta T$ $= (0.0792 + 4.166 \times 10^{-3}) \times 1.25 \times 10^{3} \times (673 - 293.8)$ $= 39.575$ kW e) Unaccounted Heat loss $= 174.972 - 59.999 - 50.1523 - 39.575$ $= 25.3037$ kW	1 mark each for parameters of heat balance sheet

Heat Balance sheet

Heat Supplied			Heat Utilized		
a) Heat supplied	174.972	100%	a) Heat => bP	59.999	34.29
			b) Heat carried away by cooling water	50.1523	28.66
			c) Heat carried away by exhaust flue gases	39.575	22.58
			d) Unaccounted heat loss	25.3037	14.46
	174.972	100%		174.972	100%

Q.3	a)	Euro norms refer to the permissible emission levels, for both petrol and diesel vehicles, which have been implemented in Europe. However, the government in India has adopted the Euro norms for available fuel quality and the method of testing.	2 marks Description 2 marks norms

Euro standard	Introduction date		Emission limits		
	New approvals	All new registrations	Petrol NOx	Diesel NOx	Diesel PM
Euro-1	1 July 1992	31 December 1992	0.97g/km*	0.97g/km*	0.14g/km
Euro-2	1 January 1996	1 January 1997	0.5g/km*	0.9g/km* (direct injection)	0.1g/km
Euro-3	1 January 2000	1 January 2001	0.15g/km	0.5g/km	0.05g/km
Euro-4	1 January 2005	1 January 2006	0.08g/km	0.25g/km	0.025g/km
Euro-5	1 September 2009	1 January 2011	0.06g/km	0.18g/km	0.005g/km
Euro-6	1 September 2014	1 September 2015	0.06g/km	0.08g/km	0.0045g/km

b)	An increased diesel engine population has created pressures on controlling diesel PM and NOx emissions. The initial progress in diesel emission control was achieved through engine technologies, including changes in the combustion chamber design, improved fuel systems, charge air cooling, and special attention to lube oil consumption. Emission standards implemented in the 2005-2010 timeframe additionally require the use of exhaust aftertreatment methods on new diesel engines. These methods include diesel particulate filters, urea-SCR catalysts, and NOx adsorbers. Pollutant emissions GHG emission and fuel economy Emission control technology • Fuel injection • Exhaust gas recirculation • Intake boosting • Combustion chamber design	2 marks each
b)	• Green Fuel. Commonly referred to as the green fuel because of its lead and sulphur free character, CNG reduces harmful emissions • Safe Fuel. The properties of CNG make it a safe fuel • High auto ignition temperature • Low operational cost • Dual facility • Increased life of oils	1 mark each