UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2005/2006

April/May 2006

EKC 367E – Plant Safety
[Keselamatan Loji]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains ELEVEN printed pages and TWO printed pages of Appendix before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEBELAS muka surat yang bercetak dan DUA muka surat Lampiran sebelum anda memulakan peperiksaan ini.]

Instruction: Answer **FOUR** (4) questions. Answer any **TWO** (2) questions from Section A. Answer any **TWO** (2) questions from Section B.

[Arahan: *Jawab **EMPAT** (4) soalan. Jawab mana-mana **DUA** (2) soalan dari Bahagian A. Jawab mana-mana **DUA** (2) soalan dari Bahagian B.]*

[Pelajar dibenarkan menjawab semua soalan dalam Bahasa Inggeris ATAU Bahasa Malaysia ATAU kombinasi kedua-duanya.]

...2/-

Section A : Answer any TWO questions.
Bahagian A : Jawab mana-mana DUA soalan.

1. [a] Accident statistics do not include total number of deaths from a single incident. Accident statistics is somewhat misleading in this respect. Justify the statement from two different examples of accidents on the basis of OSHA incidence rate and FAR.

[4 marks]

[b] A car leaves a city and travels 3000 km distance to reach another city at an average speed of 60 kmph. An alternative travel plan is to fly on a commercial air line for 4 hr. What are the FARs for two methods of transportation? Which travel method is safer, based on the FAR?

Data given: FAR for car - 57
FAR for air – 240

[6 marks]

[c] Discuss on the following:

[i] Effective dose, ED

[ii] Toxic dose, TD

[iii] Lethal dose, LD

[6 marks]

[d] Explain graphically how a toxicant A at lower dose is less toxic than toxicant B. But at higher dose toxicant A is more toxic than toxicant B.

[3 marks]

[e] Estimate the exposure concentration in ppm that will result in fatalities for 80% of the exposed individuals if they are exposed to chlorine for 4 minutes.

Table Transformation from Percentages to Probits[1]

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

...3/-

Data given:
Causative variable for chlorine deaths: $\sum C^{2.0}T$
Where C = concentration (ppm); T = time interval (min)
Probit parameters: $k_1 = -8.29$, $k_2 = 0.92$

[6 marks]

1. *[a]* *Statistik kemalangan tidak menyertakan jumlah bilangan kematian bagi satu-satu kejadian. Jika dilihat dari sudut ini, statistik kemalangan adalah agak mengelirukan. Berikan justifikasi untuk kenyataan ini melalui dua contoh kemalangan yang berbeza berdasarkan kadar kejadian OSHA dan FAR.*

[4 markah]

[b] *Sebuah kereta meninggalkan sebuah bandaraya dan berjalan sejauh 3000 km untuk sampai ke sebuah bandaraya lain pada laju purata 60 km sejam. Suatu rancangan perjalanan alternatif ialah dengan menaiki pesawat komersial selama 4 jam. Apakah FAR bagi kedua-dua kaedah pengangkutan di atas? Berdasarkan FAR kaedah pengangkutan manakah yang lebih selamat?*

Diberi data : FAR bagi kereta = 57
FAR bagi pesawat = 240

[6 markah]

[c] *Bincangkan yang berikut:*

[i] *Dos berkesan, ED*

[ii] *Dos toksik, TD*

[iii] *Dos maut, LD*

[6 markah]

[d] *Terangkan dengan graf bagaimana bahan toksik A pada dos yang rendah adalah kurang toksik daripada bahan toksik B tetapi pada dos yang tinggi, A adalah lebih toksik dari B.*

[3 markah]

[e] *Anggarkan kepekatan pendedahan (dalam ppm) yang akan mengakibatkan kematian bagi 80% daripada sekumpulan individu yang telah terdedah kepada klorin selama 4 minit.*

Jadual Transformation from Percentages to Probits[1]

%	0	1	2	3	4	5	6	7	8	9
0	—	2.67	2.95	3.12	3.25	3.36	3.45	3.52	3.59	3.66
10	3.72	3.77	3.82	3.87	3.92	3.96	4.01	4.05	4.08	4.12
20	4.16	4.19	4.23	4.26	4.29	4.33	4.36	4.39	4.42	4.45
30	4.48	4.50	4.53	4.56	4.59	4.61	4.64	4.67	4.69	4.72
40	4.75	4.77	4.80	4.82	4.85	4.87	4.90	4.92	4.95	4.97
50	5.00	5.03	5.05	5.08	5.10	5.13	5.15	5.18	5.20	5.23
60	5.25	5.28	5.31	5.33	5.36	5.39	5.41	5.44	5.47	5.50
70	5.52	5.55	5.58	5.61	5.64	5.67	5.71	5.74	5.77	5.81
80	5.84	5.88	5.92	5.95	5.99	6.04	6.08	6.13	6.18	6.23
90	6.28	6.34	6.41	6.48	6.55	6.64	6.75	6.88	7.05	7.33
%	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
99	7.33	7.37	7.41	7.46	7.51	7.58	7.65	7.75	7.88	8.09

...4/-

Data yang diberi:
Pembolehubah penyebab kematian klorin: $\sum C^{2.0}T$
Di mana C = kepekatan (ppm); T = sela masa (min)
Parameter probit: $k_1 = -8.29$, $k_2 = 0.92$

[6 markah]

2. [a] What is the purpose of Process Safety Management?

[2 marks]

[b] Discuss on various sections of Process Safety Management.

[7 marks]

[c] Explain the following terms:

[i] TLV-TWA

[ii] TLV-STEL

[iii] TLV-C

[3 marks]

[d] Write short notes on the use of local ventilation system and describe its advantages and disadvantages.

[5 marks]

[e] In solvent filling operation, 20,000 lit tanks are being filled with ethyl acetate (molecular weight = 88) at the rate of one tank in every 6 hours under ambient pressure. The filling hole in a tank is 8 cm in diameter. Estimate the concentration of ethyl acetate vapor as a result of this filling operation. The ventilation rate is estimated as 100 m^3/ min.

Data given:

P^{sat} for ethyl acetate = 105 mmHg
K^{water} = 0.83 cm/s
Φ=0.5

[8 marks]

2. *[a] Apakah tujuan Pengurusan Keselamatan Proses?*

[2 markah]

[b] Bincangkan bahagian-bahagian Pengurusan Keselamatan Proses.

[7 markah]

[c] Terangkan istilah-istilah berikut:

[i] TLV-TWA

[ii] TLV-STEL

[iii] TLV-C

[3 markah]

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[d] Tulis nota ringkas mengenai penggunaan sistem pengalihudaraan setempat dan huraikan kelebihan serta kekurangannya.

[5 markah]

[e] Dalam operasi pengisian pelarut, tangki-tangki bersaiz 20,000 liter akan diisi dengan etil asetat (berat molekul = 88) pada kadar 6 jam untuk setiap tangki di bawah tekanan ambien. Lubang isian pada tangki mempunyai garis pusat 8 sm. Anggarkan kepekatan wap etil asetat akibat daripada operasi pengisian ini. Kadar penyahudaraan dianggarkan 100 m^3/ min.

Data yang diberi:

P^{tepu} *bagi etil asetat = 105 mmHg*
K^{air} *= 0.83 sm/s*
Φ*=0.5*

[8 markah]

3. [a] Describe the parameters which affect atmospheric dispersion of toxic materials.

[5 marks]

[b] Derive the fundamental equation of dispersion model for a toxic material taking into account wind velocity, eddy diffusivity effect on the pollutant together with appropriate boundary and initial conditions.

[8 marks]

[c] Discuss on the use and limitations of Pasqill-Gifford model.

[3 marks]

[d] A 3 cm (internal diameter) pipe has broken off from a 1-ton tank containing nitrogen. Estimate the maximum mass flow rate (in kg/s) of the gas if the initial pressure of the tank is 800 kPa gauge. The temperature is 27°C, and the ambient pressure is 1 atm.
Data given:

$C_0 = 1.0$
$\gamma = 1.4$
$g_c = 1$ (kg m/s^2)/N
$R_g = 8.314$ kPa m^3 /kg-mol K
1 atm. = 101.3 kPa
1 Pa = 1 N/m^2

Useful relation:

$$(Q_m)_{chocked} = C_0 A P_0 \sqrt{\frac{\gamma g_c M}{R_g T_0}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

$$\frac{P_{chocked}}{P_0} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

[9 marks]

...6/-

3. *[a] Huraikan parameter-parameter yang mempengaruhi serakan atmosfera bahan-bahan toksik.*

[5 markah]

[b] Terbitkan persamaan asas model serakan bagi bahan toksik dengan mengambil kira halaju angin, kesan kemeresapan pusar ke atas pencemar berserta syarat-syarat sempadan dan awal yang bersesuaian.

[8 markah]

[c] Bincangkan mengenai penggunaan dan had-had model Pasqill-Gifford.

[3 markah]

[d] Sebatang paip dengan garis pusat dalaman 3 sm telah tercabut dari tangki 1-ton yang mengandungi nitrogen. Anggarkan kadar aliran jisim maksimum gas (dalam kg/s) jika tekanan awal tangki ialah 800 kPa (tolok). Suhu adalah 27°C, dan tekanan ambien ialah 1 atm.
Data yang diberi:

$C_0 = 1.0$
$\gamma = 1.4$
$g_c = 1\ (kg\ m/s^2)/N$
$R_g = 8.314\ kPa\ m^3/kg\text{-}mol\ K$
$1\ atm. = 101.3\ kPa$
$1\ Pa = 1\ N/m^2$

Hubungan berguna:

$$(Q_m)_{tersengkang} = C_0 A P_0 \sqrt{\frac{\gamma g_c M}{R_g T_0}\left(\frac{2}{\gamma+1}\right)^{\frac{\gamma+1}{\gamma-1}}}$$

$$\frac{P_{tersengkang}}{P_0} = \left(\frac{2}{\gamma+1}\right)^{\frac{\gamma}{\gamma-1}}$$

[9 markah]

Section B : Answer any TWO questions.
Bahagian B : Jawab mana-mana DUA soalan.

4. [a] Define the following terms

[i] Flammability Limit

[ii] Minimum Oxygen Concentration

[iii] Flash Point

[iv] Autoignition temperature

[v] Deflagration

[5 marks]

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[b] A container containing 70% by weight propane and 30% by weight butane accidentally ruptured at MZAB Chemi Sdn Bhd and formed a vapour cloud. The cloud was ignited 10 seconds later and resulting a huge explosion that caused partial demolition of surrounding houses within 500m from the source. By using TNT method, determine the quantity of propane and butane released in kilogram.

[20 marks]

Data:

Standard heat of formation, H_f^o

C_3H_8 = - 103.8 kJ/mol
C_4H_{10} = - 124.7 kJ.mol
CO_2 = - 393.5 kJ/mol
H_2O = - 241.8 kJ/mol
Molecular weight of propane = 44 kg/kmol
Molecular weight of butane = 58 kg/kmol
Equivalent energy of TNT = 4692.8 kJ/mol
Ambient pressure at 1 atm = 14.7 psi = 101.3 kPa

4. *[a] Takrifkan sebutan-sebutan berikut:*

[i] Had Kemudahbakaran

[ii] Kepekatan Minima Oksigen

[iii] Titik kilat

[iv] Suhu auto kebolehbakaran

[v] Deflagrasi

[5 markah]

[b] Sebuah tangki yang mengandungi 70% berat propana dan 30% berat butana telah pecah di MZAB Chemi Sdn Bhd dan menyebabkan suatu wap awan terbentuk. Wap awan itu tercucuh 10 saat kemudian dan menyebabkan satu letupan besar berlaku yang menyebabkan kemusnahan separa rumah-rumah sekitar 500 m daripada punca letupan. Dengan menggunakan kaedah TNT, tentukan kuantiti propana dan butana yang terbebas dalam kilogram.

[20 markah]

Data:

Haba Pembentukan Piawai, H_f^o

C_3H_8 = - 103.8 kJ/mol
C_4H_{10} = - 124.7 kJ.mol
CO_2 = - 393.5 kJ/mol
H_2O = - 241.8 kJ/mol
Berat Molekul Propana = 44 kg/kmol
Berat Molekul Butana = 58 kg/kmol
Tenaga setara TNT = 4692.8 kJ/mol
Tekanan persekitaran 1 atm = 14.7 psi = 101.3 kPa

...8/-

5. [a] Explain the meaning of the following terms:

[i] No

[ii] More

[iii] Less

[iv] Reverse

[v] As well as

[5 marks]

[b] Figure Q. 5 shows the flammable liquid storage tank (T-1). The storage tank is equipped with safety relief valve RV-1 via valve V-8. Nitrogen gas is used to inert the flammable liquid via control valve PV-2 to prevent fire accident. In addition, the storage tank is equipped with temperature indicator alarm (TIA-1) and level indicator alarm (LIA-1). The flammable liquid is pumped to the process stream via pump P-1, flowing through valve V-4 and control valve FV-1. Perform HAZOP analysis on the storage tank by using the following deviations

[i] High Pressure

[ii] Low Pressure

[iii] High Level

[iv] Low level

[v] High Temperature

[vi] Low Temperature

[20 marks]

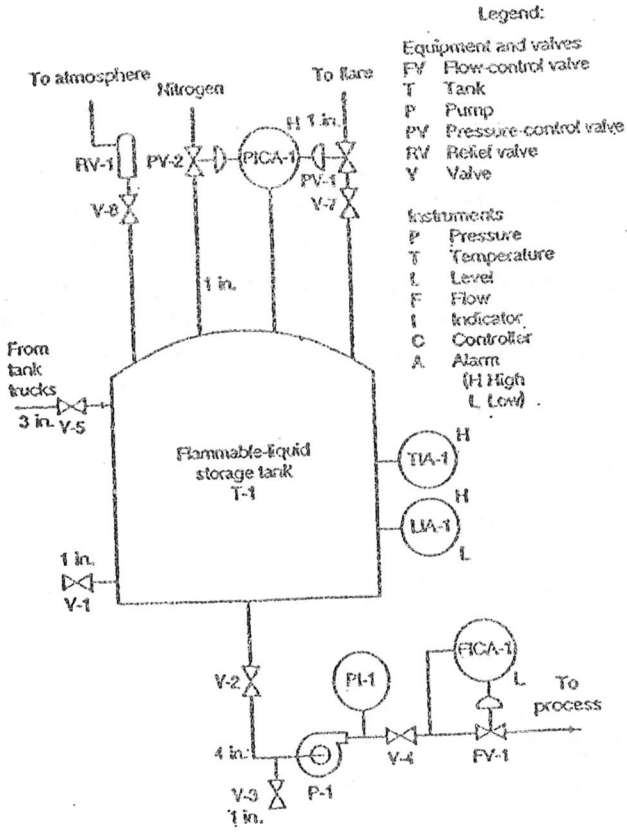

Figure Q. 5

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5. [a] *Terangkan maksud-maksud berikut:*

[i] Tidak

[ii] Lebih

[iii] Kurang

[iv] Songsang

[v] Bersama-sama

[5 markah]

[b] *Rajah S. 5 menunjukkan sebuah tangki (T-1) simpanan cecair mudah bakar. Tangki itu dilengkapi dengan injap pelega keselamatan RV-1 melalui injap V-8. Gas nitrogen digunakan untuk melengaikan cecair mudah bakar itu melalui injap kawalan PV-2 untuk mengelakkan kebakaran. Sebagai tambahan, tangki itu juga dilengkapi dengan penggera penunjuk suhu (TIA-1) dan penggera penunjuk aras (LIA-1). Cecair mudah bakar itu dipamkan ke aliran proses dengan menggunakan pam P-1, mengalir melalui injap V-4 dan injap kawalan FV-1. Lakukan analisa HAZOP ke atas tangki simpanan tersebut dengan menggunakan sisihan-sisihan*

[i] Tekanan Tinggi

[ii] Tekanan Rendah

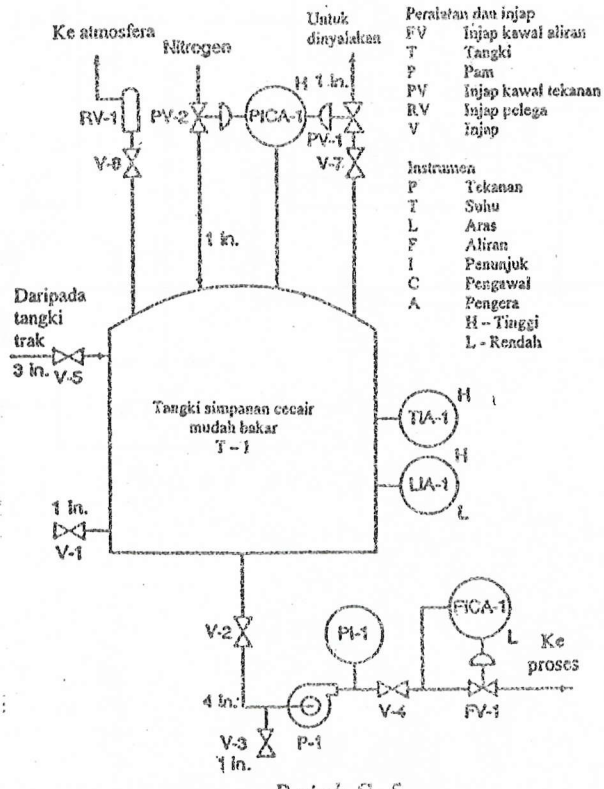
[iii] Aras Tinggi

[iv] Aras Rendah

[v] Suhu Tinggi

[vi] Suhu Rendah

[20 markah]



Rajah S. 5

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6. Figure Q. 6 shows a schematic diagram of a gas-fired furnace that is commonly used for heating process. The hot combustion gases pass through a heat exchanger to heat fresh air for space heating. The gas flow is controlled by an electric solenoid valve connected to a thermostat. The gas is ignited by a pilot light flame. A high temperature switch shuts off all gas in the event of high temperature.

[a] Determine the various ways in which this system can fail, leading to excessive heating and possible fire

[10 marks]

[b] Construct a Fault Tree Diagram for the top event of "Excessive Heating".

[10 marks]

[c] Suggest 2 ways to prevent combustible gas entering the furnace, heat exchanger and chimney in case of the failure of the pilot light.

[5 marks]

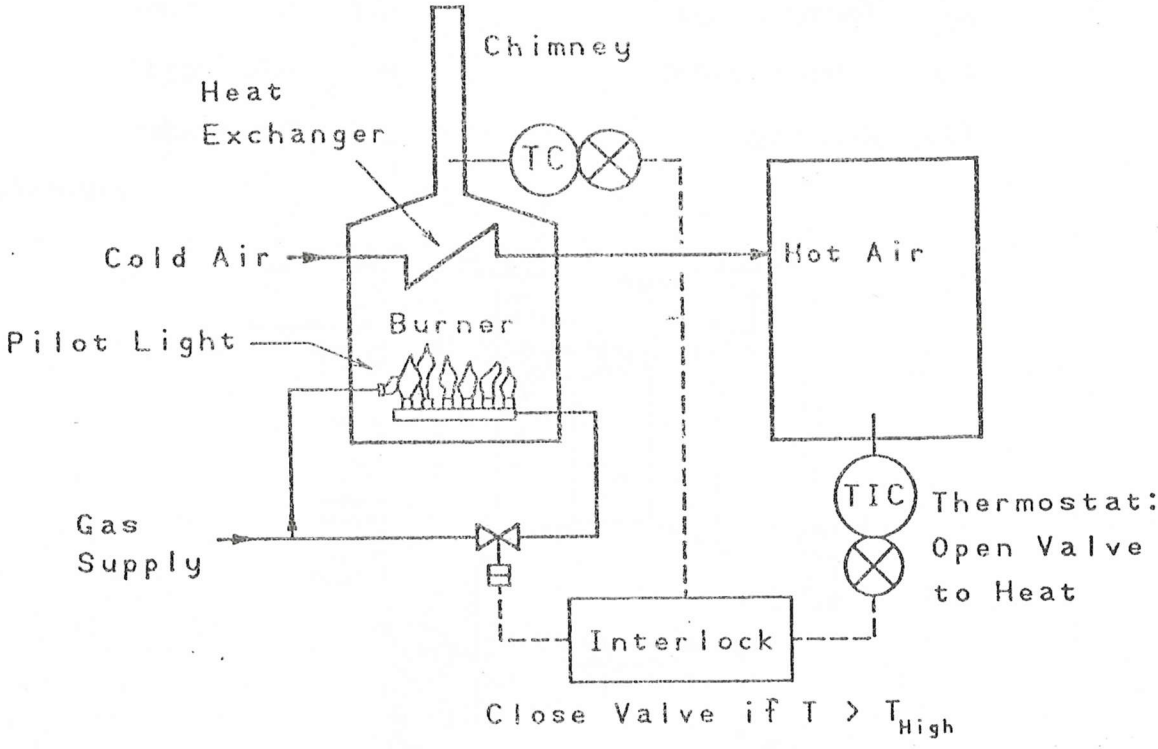

Figure Q. 6

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6. *Rajah S. 6 menunjukkan gambarajah skema satu kebuk pembakaran gas yang selalu digunakan bagi proses pemanasan. Gas-gas pembakaran yang panas akan melalui sebuah penukar haba untuk memanaskan udara bagi pemanasan ruang. Aliran gas dikawal oleh sebuah injap elektrikal solenoid yang disambungkan kepadanya sebuah pengawal suhu. Gas tersebut dicucuhkan dengan menggunakan sebuah pencucuh pandu. Suiz suhu tinggi akan menutupkan aliran gas sekiranya berlaku suhu tinggi.*

[a] *Tentukan pelbagai cara di mana sistem itu boleh gagal, menyebabkan pemanasan berlebihan dan kemungkinan kebakaran*

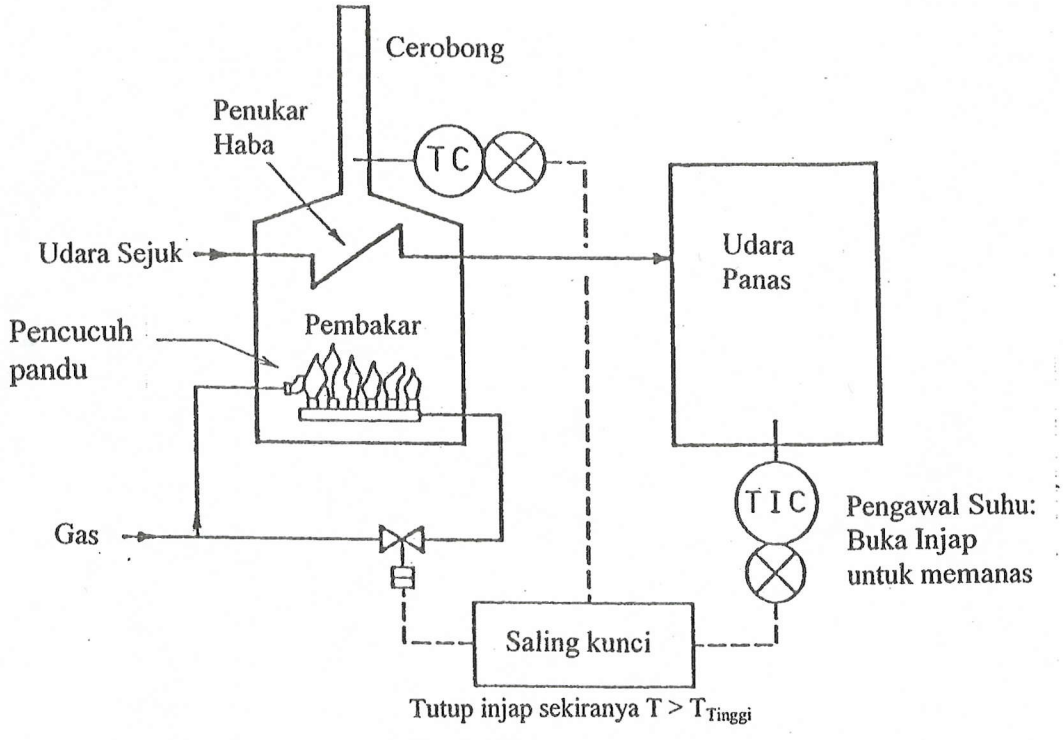
[10 markah]

[b] *Bangunkan gambarajah Pokok Kegagalan bagi peristiwa atas "Pemanasan Berlebihan".*

[10 markah]

[c] *Cadangkan 2 cara untuk mengelakkan kemasukan gas mudahbakar di dalam kebuk pembakaran, penukar haba dan cerobong sekiranya kegagalan pencucuh pandu.*

[5 markah]



Rajah S. 6

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Lampiran

Damage Estimates for Common Structures Based on Overpressure (these values are approximations)[1]

Pressure		Damage
psig	kPa	
0.02	0.14	Annoying noise (137 dB if of low frequency, 10–15 Hz)
0.03	0.21	Occasional breaking of large glass windows already under strain
0.04	0.28	Loud noise (143 dB), sonic boom, glass failure
0.1	0.69	Breakage of small windows under strain
0.15	1.03	Typical pressure for glass breakage
0.3	2.07	"Safe distance" (probability 0.95 of no serious damage below this value); projectile limit; some damage to house ceilings; 10% window glass broken
0.4	2.76	Limited minor structural damage
0.5–1.0	3.4–6.9	Large and small windows usually shatter; occasional damage to window frames
0.7	4.8	Minor damage to house structures
1.0	6.9	Partial demolition of houses, made uninhabitable
1–2	6.9–13.8	Corrugated asbestos shatters; corrugated steel or aluminum panels, fastenings fail, followed by buckling; wood panels (standard housing), fastenings fail, panels blow in
1.3	9.0	Steel frame of clad building slightly distorted
2	13.8	Partial collapse of walls and roofs of houses
2–3	13.8–20.7	Concrete or cinder block walls, not reinforced, shatter
2.3	15.8	Lower limit of serious structural damage
2.5	17.2	50% destruction of brickwork of houses
3	20.7	Heavy machines (3000 lb) in industrial buildings suffer little damage; steel frame buildings distort and pull away from foundations
3–4	20.7–27.6	Frameless, self-framing steel panel buildings demolished; rupture of oil storage tanks
4	27.6	Cladding of light industrial buildings ruptures
5	34.5	Wooden utility poles snap; tall hydraulic presses (40,000 lb) in buildings slightly damaged
5–7	34.5–48.2	Nearly complete destruction of houses
7	48.2	Loaded train wagons overturned
7–8	48.2–55.1	Brick panels, 8–12 in thick, not reinforced, fail by shearing or flexure
9	62.0	Loaded train boxcars completely demolished
10	68.9	Probable total destruction of buildings; heavy machine tools (7000 lb) moved and badly damaged, very heavy machine tools (12,000 lb) survive
300	2068.	Limit of crater lip

[1]V. J. Clancey, "Diagnostic Features of Explosion Damage," paper presented at the *Sixth International Meeting of Forensic Sciences* (Edinburgh, 1972).

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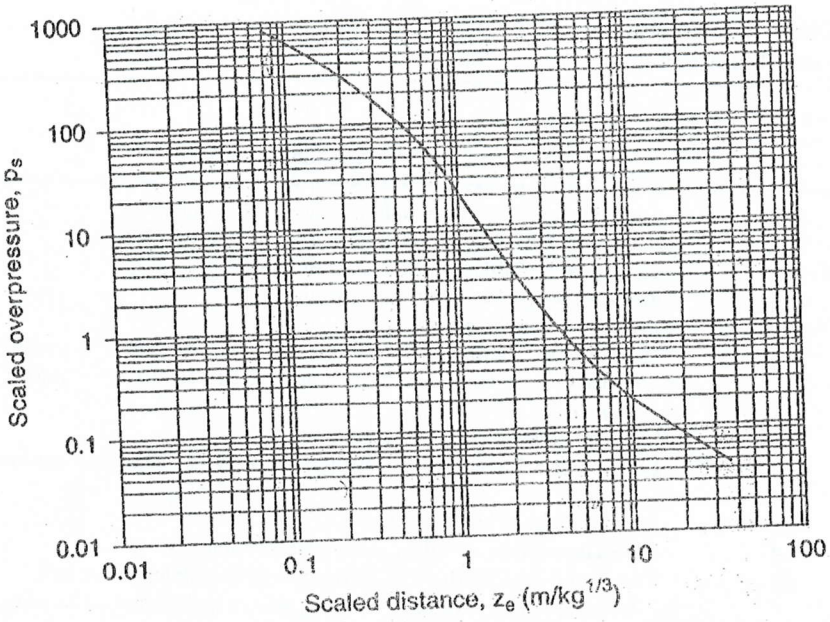

Correlation between scaled distance and explosion peak side-on overpressure for a TNT explosion occurring on a flat surface. Source: G. F. Kinney and K. J. Graham, *Explosive Shocks in Air* (Berlin: Springer-Verlag, 1985).

$$\frac{p_o}{p_a} = \frac{1616\left[1 + \left(\frac{z_e}{4.5}\right)^2\right]}{\sqrt{1 + \left(\frac{z_e}{0.048}\right)^2}\sqrt{1 + \left(\frac{z_e}{0.32}\right)^2}\sqrt{1 + \left(\frac{z_e}{1.35}\right)^2}}$$